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Tracks for Railway Curves.

The steady and rapid increase in the weight and speed of locomotives has created important changes in railway track conditions, particularly on curves. There has been no "theory" of track construction, but the present types have been developed by experience and observation. It is probable that not a dozen railway officials in the country have ever attempted to analyze the mechanics of curve resistance and to determine from a theoretical standpoint the overturning effort on the rails and the shear on the spikes. There has been no need for such a study, for experience has shown until recently that the track was perfectly able to take care of its loads and shocks. But trackmen have noticed lately where some of the new types of locomotives are used for fast heavy passenger service that even the best construction required so much maintenance that it seemed likely the track had about reached its safe carrying capacity. Spreading of gauge has come to be feared even on the best main lines, and there has developed a feeling that electric locomotives like those of the New York Central must impose on the track materially greater stresses on curves under rapidly moving trains than steam locomotives.

Although the steam locomotive is a machine of unbalanced internal forces and thus impresses upon the track at every revolution of its drivers blows of substantial magnitude in a vertical direction, the greatest resisting capacity of the track is in the same direction. While, therefore, this particular condition may be a source of care and expense in maintaining the track, it tends but little toward producing an accident to a moving train. Similarly the greater height of the center of gravity of a steam locomotive compared with that of an electric machine adapted to the same service creates an additional tendency to overturning on curves, although it does not of itself increase the actual force exerted by the outer rail against the driving wheel flange in compelling the locomotive to take its curved path. The centrifugal or deviating force, as Rankine properly insisted upon calling it, will obviously be the same in the two types of engines as long as the weight and speed are the same, but the higher center of gravity of the steam machine will cause a proportionately greater overturning moment. The latter will tend to produce a correspondingly greater wheel load upon the outer rail than upon the inner, and the greater the load upon the rail the greater will be the frictional resistance to the movement of the base of the outer rail on its support. With the heavy driving wheel loads of the present day this frictional resistance to outward movement of the outer rail constitutes a material relief in the duty of the rail fastenings to resist the outward pressure of the driving wheel flanges on curves, and may mean in some cases the difference between failure of the fastenings and their immunity from it. The complications due to locomotive construction and radial and longitudinal slip of wheels on curved rails make a complete mathematical analysis of wheel-rail pressures impracticable, although an approximate one is not very difficult to outline.

This whole subject of resistance of track on curves has been brought into prominence by the recent accident to an electric express train on the Harlem division of the New York Central R. R., in the Borough of The Bronx, New York City. The train was moving at a high rate of speed on a three-degree curve, but the speed was not such that a track should not be able to sustain it safely for an indefinite period of time. It is considered not improbable by some engineers that the accident was produced by an outward thrust upon the outer rail of the curve sufficient to shear off the heads of the spikes holding it on the plates. The track at this particular curve had shown signs of weakness prior to the accident, but no evidence had been made public at the investigations into the accident which shows that the rail fastenings had been disturbed to any appreciable extent by the heavy steam locomotives frequently passing over it. It is not impossible, therefore, that the margin of safety may have been sufficient to enable the trains to pass the curve in safety, but was inadequate to resist a heavy train moving with the high speed of the electric train which was partially derailed. This is manifestly a most important consideration, and has stimulated a careful examination of the conditions resulting from the use of the two types of locomotives, which is reported elsewhere in this issue.

There are also some detail features of the action between the locomotive and the outer rail which need much experimental investigation. The assumptions that have to be made in order to apply theory to practice are now too many to make theory as valuable as it should be. The determination of exact values of the forces acting between driving wheel flanges and the outer rail with a given weight of locomotive, length of rigid wheel base and speed of train, is too complicated to be solved, except approximately, by mathematics. Allowances can be made for friction and for the approximate conditions of the machine as it rounds the curve at a given speed, but the influences of the play of its different parts, the unavoidable unevennesses of track and other agencies cannot be well defined. Furthermore, in such a problem it is essential that the worst conditions which may possibly exist should be those assumed in computing the thrust of the wheel flanges against the outer rail. The construction of both steam and electric locomotives is such that the maximum pressure exerted by one wheel may be quite heavy at high speeds, which shows that not only should the design of wheel flanges be carefully studied, but the strength of track on curves should be thoroughly investigated. There is no feature of railway engineering that is in a more backward condition in America to-day than track construction, for while the general design is carefully worked out the actual construction and maintenance are likely to be entrusted to men who fail to appreciate that one rusted spike on a railway curve under heavy fast traffic may result in many deaths. The computations made by the engineers of the New York Central, General Electric and American Locomotive Companies indicate that, on the assumptions made, the track on the curve where the accident occurred was good enough to resist destruction, if it had been in proper condition. The mere fact of the accident proves, however, that either the assumptions on which the computations were based were incorrect or the track was not in good condition, or some hard body fell between the rail and wheels. The testimony up to the present time indicates the last two were probably contributing causes; whether they were the sole causes cannot be determined until the mechanics of curve resistance, the friction of rails on tie plates, the slip of wheels, the play of the parts of the locomotive and other things now uncertain, are better known.

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The State Control of Water Supplies.

There is no longer any doubt possible that the people of the country generally are fairly awake to the importance of water supplies, formerly neglected and befouled in the most thoughtless manner. Not only is the amount of water available for potable purposes becoming scarce in some localities, except at the cost of enormously expensive works for developing distant supplies, but it does not call for much careful consideration to detect in the conflicting claims of public and private interests to the same catchment basins for water for potable and power purposes the germs of bitter legal controversy and the possibility of many miscarriages of justice at times when popular feeling runs high. Then, again, the contamination of water by refuse of one sort or another is rapidly becoming a condition so widespread that already a number of States have passed laws regulating it more or less. It therefore seems likely that before very long the doctrine that the State owns the unappropriated water supplies within its boundary will not only be acknowledged generally, but will be the foundation on which some sort of State control of water supplies will rest, entirely apart from the control which is exercised as a measure to improve the condition of the public health.

There are few subjects which will be found to have more complex relations with other interests. In one State, Pennsylvania, where a public water supply commission was constituted some time ago, the law governing it was purposely so drawn that one of the commission's most important functions was to investigate all the conditions governing the conservation and uses of water in the State and to report such recommendations for further legislation as it considered desirable to bring about an equitable and economical development of the water resources. For this reason the commission's work is of special value, and particular attention is called to the abstract elsewhere in this issue of the latest report it has issued, in which a variety of laws are recommended. This report is of particular interest because the recommendations made do not lie so closely along the lines of engineering inquiry as some of those that have been suggested elsewhere, but relate rather to the far more important fundamental principles which ought to be settled as soon as possible in order that future legal complications over water rights may be reduced to a minimum. The commission has apparently decided that its first duty is to ascertain what are the water resources of the State, how they are utilized at present and what are the claims of various parties to water from the same source. Questions like these are really more important, except from the standpoint of public health, than those relating to contamination by refuse and similar related subjects. The latter are already under the control in Pennsylvania of a State commission armed with strong powers, and consequently there is no danger that they will be dragged into the undue prominence they are receiving in some other States. When it is reflected that the practice of sewage treatment preparatory to its discharge into streams is still in the evolutionary stage, it is easy to understand why legislation regarding it must be approached with extreme caution and no hard and fast laws can be passed regarding it without incurring the danger of doing injustice to some interests. There are none of these technical uncertainties regarding the more important broad features of State control of water supplies, however, and accordingly the pioneer work of the Pennsylvania commission is likely to be of general value.

The subject gains added interest from the fact that at the suggestion of Governor Stokes of New Jersey a bill has been introduced in the legislature of that State authorizing the appointment of a New Jersey public water supply commission. In some respects this bill is the most interesting evidence that has yet appeared of an awakened appreciation of the importance of the subject. It contains the customary requirements regarding the approval by the commission of all projects for an additional water supply, but in addition the commission is given power to require all public and private water-works organizations to report to it the amount of water they supply, the rates charged, the communities to which they furnish water and such other information as the commission may need for a proper supervision of the water supplies of the State and their utilization. Special stress is laid in the bill on the necessity for each water-works organization to determine "by meters or other approved methods" the amount of water used. In addition, the commission is specifically charged with the duty of examining all projects for the storage of flood waters, which is a most important subject in the northern part of the State. The most important feature of the bill is, however, that expressed as follows:

"Every municipality, water company or private person now diverting the waters of streams or lakes, with outlets, for the purpose of a public water supply, shall make annual payments to the State Treasurer for all such waters hereafter diverted in excess of the amount now being diverted. And every municipality, water company or private person not at present diverting surface water for said purpose, but who shall hereafter divert such waters, shall make annual payments to the State Treasurer for all water diverted in excess of 100 gal. daily for each inhabitant of said municipality, as shown by the census of 1905. The amount of such payments shall be fixed by said commission at a rate not less than $1 nor more than $20 per million gallons. The commission shall fix a low rate in case flood waters are impounded by storage reservoirs and utilized and shall increase the rate in case the dry season flow of the stream is encroached upon or diminished."

The bill designates the manner of collecting these sums, which are to be credited to a fund for the conservation and control of the water supplies of the State. It should be stated in explanation of the section of the bill just quoted that the highest court of the State has recently decided all surface waters to be the property of the State and the latter is accordingly enabled to take a more positive stand regarding their use than might be practicable without prolonged litigation in States where this subject has not been adjudicated. Whether all the provisions of the bill are couched in the best language to avoid future disputes and ensure an equitable use of the waters of the State can only be determined by a more careful consideration than this journal has been able to give it as yet. It is certain that its basic principles are deserving of the warmest support, and if the bill contained provisions for ascertaining the extent of the water supplies of the State and was extended so that the commission would have authority over the uses of water for power and industrial as well as municipal purposes, it would be still better.

Another Candle-Power Dispute.

The tangled mess which will result from an attempt to call anything by a term meaning something else is well shown by existing complications over the electric street lighting in Colorado Springs. The wrangle in this case is over the meaning of the old term, "2,000 candle-power light." Its commercial signification is so independent of the ordinary meaning of the words that some years ago the National Electric Light Association voted that 2,000 candle-power did not mean 2,000 candle-power when applied to arc lights, but meant something else. All this was useful to those acquainted with the ruling of the Association, but, unfortunately, many people now engaged in public affairs are not familiar with this definition, and have a firm belief that the dictionary should be the guide to the meaning of words. When such a dispute gets into the courts, the lighting companies are generally able to prove that a lamp of 2,000 candle-power means a lamp which uses a certain amount of current, or something of that sort, and accordingly the public has to accept the "term of the trade" as interpreted by the company. Fortunately, there is now a tendency toward removing these causes of misunderstanding by legislation preventing the misuse of words even when the misuse is sanctioned by trade custom. For example, for many years a man who purchased a glass of jam labelled "raspberry" was pretty certain, unless he bought a well-established brand, to secure a concoction of syrup, glucose, gelatine and coloring matter entirely innocent of raspberry, but given a pleasing tinge of verisimilitude by a skillful mixture of hayseed through the mass. Recently, however, the government has taken this matter in hand and has decided that when a thing is labelled raspberry jam it must be that article strictly, and not some mixture which the manufacturers of such supplies have agreed to call by that name. It seems probable that the same thing will shortly be done in other industries. The need of some definite understanding regarding illumination and its measurement is very great, and while it may not be practicable for some time to devise a method of measurement which will be satisfactory, it seems that the old method is so completely antiquated that the people interested in lighting ought to get together and devise something better. If they do not do this voluntarily, it is likely that the courts will do it for them; the result of this may be some inaccurate method legally approved, like the method of estimating earthwork by averaging end areas, which is required by the courts in a good many States.

The conditions that have arisen in Colorado Springs furnish an interesting example of all the complications which follow the use of such an indefinite terms as "2,000 candle-power lamps" in legal documents. Some seven years ago, that city gave a franchise to a contractor for the use of the city water supply for power purposes, the consideration being the execution of certain heavy construction and an agreement to furnish "lights of standard 2,000 candle-power" at $5.50 per month. The city had previously been lighted by a company working under a franchise which would expire whenever the new plant was ready to begin its regular operation. The people behind this new plant, instead of carrying out their contract with the city, eventually made an agreement with the old company by which they supplied it with current at 0.6 cent per kilowatt-hour. The old company used this current in carrying out its contract for street lighting. About the time that the new works were built the company changed over its light from the old open arc lamp to the new alternating-current inclosed arc, and made a reduction in price to correspond. Since then a great many disputes have arisen over one thing or another in regard to street lighting, but in reaching an understanding in these disputes, the city has invariably stipulated that it relinquished none of its rights given it by the franchise which was awarded to the contractor who built the hydro-electric plant. It never formally accepted the enclosed arc lamps which have been used for a good many years in lighting its streets, and recently it has demanded damages for deficient lighting since the enclosed arcs were first used. It has also insisted that these damages should be measured by candle-power. The subject has been referred to three arbitrators who have already heard a great amount of expert testimony. The city claims that the standard 2,000 candle-power lamp mentioned in the franchise was an open arc using 450 watts, and that the enclosed lamps which were later employed were only in experimental use at the time the franchise was given and were not customarily rated in candle-power at all then. The company claimed that under the definition of the National Electric Lighting Association, any lamp which takes 450 watts at the arc is a 2,000 candle-power lamp within the meaning of the franchise. In other words, it insisted that although the inclosed arc lamp by no means gave as much illumination of the kind desired by the city as the old open arc lamp, nevertheless the city would have to accept it as what was stipulated in the franchise, because the definition of the National Electric Light Association made the two lamps equivalent. It is evident, therefore, that the technical and legal questions mixed up in this controversy are of a kind which may well daze the board of arbitrators. They show very plainly, moreover, the necessity of some better understanding being reached right away concerning the measurement of illumination for street lighting purposes.

It is perfectly evident that the resolution of the National Electric Light Association is no longer of any commercial benefit. The watt specification of that resolution was a good enough definition so long as none but ordinary open arc lights were in commercial use, since with such lights the condition of successful operation automatically limited the voltage at the arc and consequently the current, so that a 450-watt arc could mean practically but one thing. Since that definition was formulated, there has been great progress in arc light construction, and consequently the attempt to extend the old definition into the present state of the art is a curious evidence of the rapidity of changes in electrical practice.

The definition is wholly inadequate to the present situation. Manifestly it does not apply to the new magnetite arc light which is beginning to come into use. A watt rating of this light would be as unfair to the central station company as a watt rating of the alternating-current enclosed lamp is to the consumer. If the light is rated on candle power it receives no credit for a distribution of illumination that is particularly useful in street lighting. If illumination is considered the important point and no attention is paid to watts or the absolute flux of light, then this rating is very favorable to the incandescent gas lighting people. The Germans have partly overcome all these difficulties by adopting a mean lower hemispherical rating, which probably defines the useful effect in street lighting better than anything else, although this is not saying very much. A watt rating is plainly possible only in comparing arc lights of the same kind, and with the great variety of arc lights now being introduced, it is utterly valueless without other specifications. Now that flaming arc lights are coming into use, the subject is still further complicated, and it is therefore manifest that a new system of measurement for street lighting should be adopted, for neither watts nor actual candle-power have proved useful methods.

The controversy under arbitration in Colorado Springs is a good evidence of the fact that such vague and indefinite contract terms as a "2,000 candle-power arc light" will surely cause trouble and should be avoided. It seems like an anachronism to go into such matters at this day, but the very fact that this old cause of dispute has again arisen to cause trouble indicates that new and carefully prepared lighting specifications are very desirable.

Broad Gauge?

Among the revelations vouchsafed by Mr. Harriman upon the witness stand recently, there have been few that touched in any way upon engineering matters. Most of the facts were merely confirmatory of the evidence lately presented to the public by the suddenly reformed Mr. Lawson. But, a day or two ago, Mr. Harriman departed from the path of high finance and pecuniary hydraulics long enough to venture the prediction that the railroads will soon have to come to a six-foot gauge and reconstruct their entire systems to match. How large may be the distinguished prophet's holdings in the Steel Corporation this journal does not know, but that he expected anybody outside of the lambs whom he has so often assisted in shearing to take the prediction seriously is very much in doubt. Broad-gauge roads there used to be in this country, but they had no virtues that anybody was able to detect from a practical standpoint and were at large cost changed to the present standard gauge. In fact experience abroad has failed to disclose any good reason for broad gauge, and the tendency is to abandon rather than to encourage it. The only gain that the public would observe in its use would be added space in sleeping cars, and, so far as reports go, passenger traffic was about the last thing considered by Mr. Harriman in his extraordinary statement.

Unquestionably a broad gauge road would be enabled to operate much larger freight cars than are now usual and by putting down stronger track and building bigger locomotives it would be possible to haul much heavier trains than at present, at therefore, somewhat lessened cost to the railroads. What is vastly more important, the change would cost several thousand millions actual cash, and would give opportunity for printing several times that amount in securities to be issued to insiders at a discount and passed up to a new generation of lambs at a large premium. Does anybody for a moment dream that the change would lower freight rates, with the watering pot wielded in this Titanic fashion? The fact is that shippers are suffering acutely to-day, not for lack of broad-gauge tracks, but from the very policy which the broad gauge is deliberately designed to encourage. The interests of the railroads and of the public are diametrically opposed in this matter. The latter wants short freight trains at close intervals, picking up shipments sharply and pushing them through, the former wants the longest trains that can be drawn run as seldom as the traffic will stand. The result is evident in the thousands of side-tracked freight cars waiting the making up of "ideal" trains. From the railroad standpoint a few broad-gauge trunk lines with all parallel lines suppressed, shipments awaiting the road's convenience and a doubled capital on which dividends can be vociferously claimed before freight rates are lowered, is just the thing to hope for. From the standpoint of the shipper and the consignee something akin to electric railway service is the thing really desirable, the full utilization of the tracks by frequent trains taking shipments promptly and giving quick service, the increase of mileage to decrease the primary haul to the station, and the existence of real competition in rates.

The thing really necessary is the full and economical utilization of the roads as we have them rather than another stage of costly reconstruction. The last year has been a very busy one for the railroads and a small shortage of equipment is keenly felt, yet few roads are worked to anything like full output of all the equipment they really could muster into service. They are working at maximum economy perhaps, but not at maximum haulage capacity. The improvement of equipment most needed is improvement in activity—the determination to keep everything on wheels moving even if more train crews are needed and more coal has to be burned. The work most needed on the lines is the lowering of grades and the smoothing out of curves, not increase of gauge. If electric traction on railways comes along it will be possible to get all the tractive effort really needed on one train by use of electric locomotives in which great power can be concentrated in a single unit. The track requirements of electric service are, other things being equal, rather less severe than with ordinary locomotives. As traffic increases heavier rails and more solid roadbeds are necessary, and in particular curves should be eased. All these changes are costly, but they are as nothing to the immense expenses of changing both the entire outfit of rolling stock and the complete permanent way, including bridges and tunnels. Frankly the broad gauge prophecy looks like a colossal bluff, an argument trumped up in defense of more high finance in the future, a bug-a-boo waved in the face of government control or ownership. The threat may act, however, as a boomerang for how will foreign capital look upon American railroads if they must be again reorganized in such wholesale fashion?

The Pittsburg Highway Convention.

Pittsburg has been the place of meeting this week of the greatest gathering of people interested in improved highways ever held in the United States. Governors, members of legislatures, highway commissioners and plain ordinary believers in improved roads have met to the number of many hundreds to discuss what shall be done to improve the country's roads. There were many enthusiastic statements about what should be done, but it was noticeable that the definite assertions as to what can be done were rather few. Although, therefore, the actual working results of the convention are probably not very great, the meetings have unquestionably been of great value. They wasted little time on considerations of disputed points of construction. Some years ago no convention of good road enthusiasts was considered complete unless somebody read a long and dreary paper on the right size of stones to use in foundation beds, the proper dimensions of ditches, and things of that sort. All such information is very valuable in its place, but it is generally recognized that at the present time the essential thing in securing improved highways throughout the country is to spread the knowledge as to what such highways mean to the people.

At the present time farmers and other classes doing heavy teaming over country roads are beginning to appreciate what help a hard surface gives to them in work of this class. With the advent of good roads in some sections of the country, the farmer has learned that he is much better off when he is able to do his hauling at the times when the results are likely to bring him the most money.

The programme at the convention was full of educational papers. They described the results of good road construction, with and without State aid, from the Atlantic to the Pacific. Probably there has never before been heard so much testimony of a reliable nature concerning the importance of improved highways to the public. Those who are preaching the gospel of good roads need the encouragement of such conventions. Their work is hard enough under any condition, for in most sections of the country the appreciation of improved highways has only begun, and the missionary work is arduous. A great convention like this, attended by governors and other distinguished public officers, at which the testimony of road builders and enthusiasts from all parts of the country was unanimously to the effect that the recognition of highway improvements was rapidly spreading, has been most encouraging. The members of the legislatures, the highway commissioners of counties and States, are the men who are now most responsible for bringing about improvements of this class, and certainly any convention which can furnish encouragement to them in their work deserves approval, even if none of the papers presented go into the details of highway construction. In fact, it may not be at all unlikely that a considerable amount of harm has been done in some sections by too much stress being laid on the actual details of road building, the result of such untimely pushing forward of technical matters being the development of a feeling that perhaps after all this movement was a combined effort between engineers, contractors and manufacturers for the purpose of securing employment and selling expensive machinery. It must be borne in mind that the farming class has for many generations been the mark of all promoters of worthless schemes. As a result it has come to look upon all new propositions with extreme suspicion, and it is not to be expected that it will soon agree to any public work which requires heavy taxes, but must be gradually convinced that such construction is really to its advantage.

THE SEVEN-FOOT POLK STREET WATER TUNNEL, CHICAGO

The new 7-ft. Polk St. cross-town water tunnel in Chicago extending under the central part of the city from the lake front to a point about half a mile west of the South Branch of the Chicago River, has a total length of 6,122 ft. and replaces an old tunnel of the same cross-section. The old tunnel, which was built nearly 20 years ago, formed a cross-connection between two land tunnels. One of these land tunnels is the continuation of an 8-ft. tunnel extending under the lake from an intake crib 4 miles off shore to a pumping station about one-half mile inland at Fourteenth St., on the south side of the city; the other is a 7-ft. land tunnel, 5 miles long, that extends from a pumping station on the north side of the city, at the end of a 10-ft. tunnel under the lake from a second crib, to a pumping station at Twenty-second St. on the south side. The flow in the old 7-ft. connecting tunnel was in either direction depending on the amount of pumping at the different stations connected with the tunnels.

The direction of the old tunnel was diagonally across the portion of the city under which it was built, without any reference to the plan of the streets on the surface. This tunnel was at a depth of from 65 to 70 ft. and was lined with three rings of brick laid in cement mortar. It was built through the various kinds of clay and loam which are over the stratum of bed rock that extends under this part of Chicago at a depth of 80 to 110 ft. The district under which this tunnel was driven is immediately south of the congested office building and retail shopping district of the city and has recently been building up very rapidly, the new buildings in many cases being on footings built on piles driven to considerable depths. Some three years ago in driving the piles for a building on Fifth Ave., about half a mile from the lake front, the old tunnel which the one in Polk St. replaces was pierced in several places so that it had to be thrown out of service. As similar conditions were liable to be encountered continually in the future, the decision was made to abandon the old tunnel, to replace it by one following under the streets and then to fill it completely.

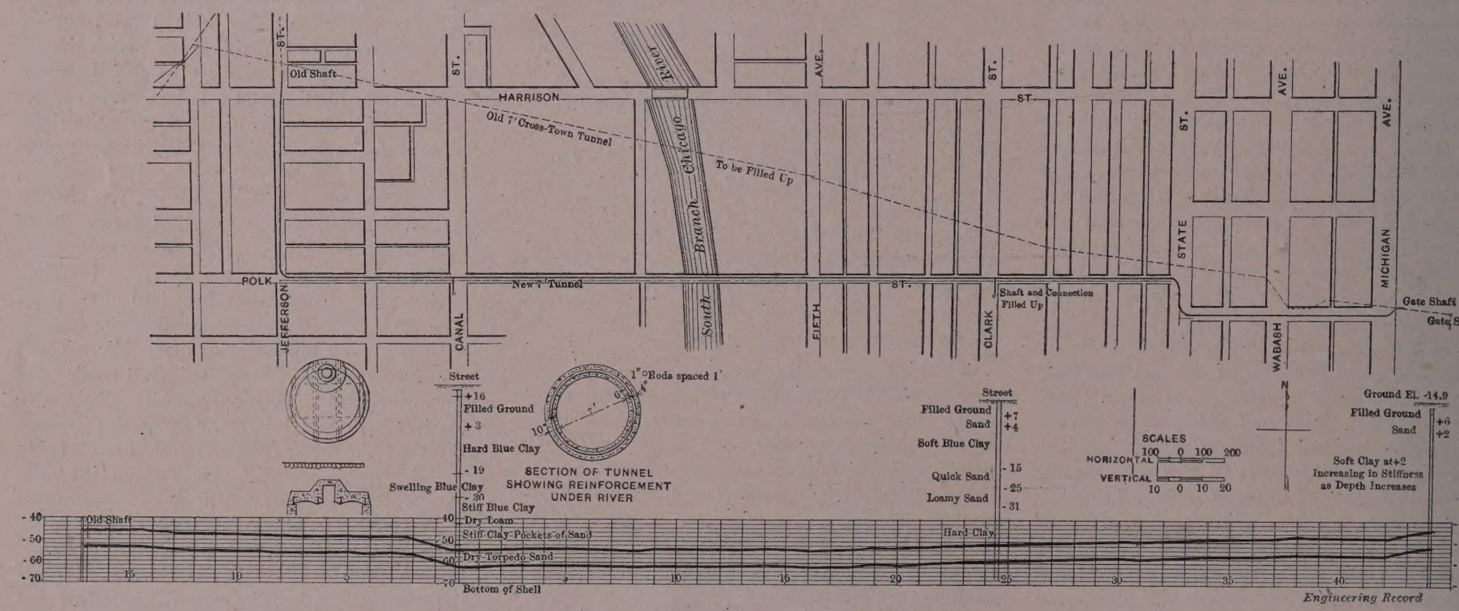
The general direction of the old tunnel is shown by a dotted line on the accompanying map and the new one by a solid line following down the center of Peck Court and Polk and Jefferson Sts. The invert of the new tunnel lies at a depth of 53 to 63 ft. below Chicago datum, the latter being the mean water level in Lake Michigan; the grade of the streets under which the tunnel passes is 15 to 21 ft. above Chicago datum. Except in a length of 640 ft. under and adjacent to the South Branch of the Chicago River, the tunnel proper is lined with at least 10 in. of concrete. In the 640-ft. length at the river the 10-in. concrete lining is reinforced with 1-in. iron hoops spaced 1 ft. apart on centers. This reinforcement was added on account of the proximity of the bottom of the river and of a 6.5x7.6-ft. freight tunnel of the Illinois Tunnel Co. The channel of the river is 160 ft. wide and about 20 ft. deep where the tunnel passes under it. The width of the channel will be increased to 200 ft. and its depth to 30 ft. when improvements under way are completed. With the proposed depth in the channel the tunnel will have a cover of about 23 ft., which is considered sufficient to permit piles to be driven, or caissons to be sunk for the piers of a new bridge carrying Polk St. over the river. The tunnel of the Illinois Tunnel Co. detours entirely out from under the street at the river crossing so that no complications are encountered with it in that portion of the water tunnel immediately under the river. From Canal St., east, however, the former tunnel is directly over the water tunnel with the exception of the detour at the river, and near each end of the river crossing the clearance between the invert of the one and the crown of the other is only 3 to 5 ft.

The original tunnel plans called for a brick lining, but after one of the shafts in connection with the tunnel and 150 ft. of the latter had been built and lined with brick, operations were temporarily suspended and the concrete lining was adopted later. The concrete is made of Portland cement and crushed limestone graded from ¼ to 1 in. in size, one part of cement to 3 parts sand and 5 parts of stone being employed.

The construction was carried on almost entirely from two shafts, one in Clark St., 1,953 ft. from the lake front end of the tunnel, and the other in Canal St., 2,445 ft. from the first shaft and 1,723 ft. from the land end of the tunnel. A third shaft was also built in the park along the lake front at the end of the new tunnel, and will contain a gate by which the flow may be cut off in the tunnel. The Clark St. shaft was sunk for construction purposes only, but the one in Canal St. is permanent. The Canal St. shaft, which has a finished diameter of 8 ft. and a total depth of 91 ft., was sunk first. Although various kinds of clay and loam were encountered in excavating for this shaft, the excavation was made without much difficulty down to within 8 ft. of the bottom, where running sand was met. Above the sand the shaft was lined with 8x10-in. timbers placed in horizontal octagonal bents; the latter were 2½ ft. apart on centers and were lagged with 3x6-in. plank. A steel shell built of ¼-in. plates was used for lining in the sand at the lower 8 ft. of the shaft. The material removed from the excavation for the shaft was brought to the surface in buckets handled by an electrically operated hoist at the surface. This shaft is 72 ft. off the center line of the tunnel, and after a connection had been driven from the bottom of it to a few feet beyond the site of the tunnel the latter was driven in both directions from this connection.

The Clark St. shaft was 7.5 ft. in diameter in the clear at the top and 7 ft. at the bottom, with a total depth of 81 ft. Owing to the character of the materials encountered it was sunk with considerable difficulty. The upper 40 ft. of the shaft was through soil that could be held in place by timbering similar to that used in the Canal St. shaft, an 8-ft. opening being left after the timbering was in place. At a depth of about 30 ft., however, a stratum of quicksand was encountered which afterward necessitated a lining of ¼-in. steel plates to be adopted below the 40-ft. level. This lining was built in sections 4 ft. long, each section being divided along the axis of the shaft in two equal parts. The two halves of each section were lowered into the shaft separately and assembled in the latter. An angle riveted vertically on the inside of both ends of each half section formed a flange, so when the ends of the halves were brought together they could be connected with bolts through holes in these flanges. An angle flange riveted horizontally on the inside at the top and bottom of each half section enabled a good connection to be made between the vertical sections. The sections of steel lining were sunk by pushing them down with jackscrews, which were first blocked against the timbering in the shaft and then against the successive sections of the lining. The latter in the upper part of the lower 40 ft. of the shaft was 7.5 ft., and the remainder 7 ft. in diameter, the smaller diameter having been adopted on account of the difficulty in sinking the lining in the hard clay encountered toward the bottom.

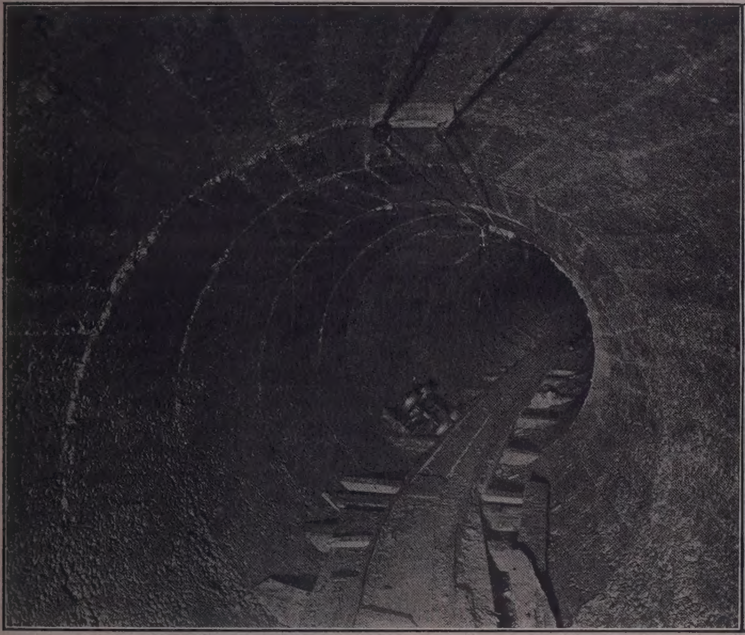
When this temporary shaft had been sunk



Plan and Profile of Polk Street Tunnel, Chicago.

it was lined from the top of the steel lining to the top of the shaft with concrete, the steel lining in the lower half and the timbering at the top being left in place for safety. This concrete lining was placed in 3-ft. vertical sections. As the shaft was 134 ft. from the center line of the tunnel, after it was completed a connection with a 4½x6-ft. horseshoe-shape cross-section was driven from it to 6 ft. beyond the tunnel. The latter was then driven in both directions from this connection, so that work was in progress in four headings during most of the time, three 8-hr. shifts being employed in each heading.

An air lock was installed in the connection between each of the shafts and the tunnel, two headings thus being served by one lock in each case. A pressure of 10 lb. was maintained throughout the work, although on a considerable part of the tunnel west of the river the pressure was not required, but was maintained to keep up the pressure at the east heading from the Canal St. shaft. The air was supplied to the tunnel by a compressor driven by a motor at the mouth of the Canal St. shaft and by a similar installation at the Clark St. shaft.



A Portion of Unfinished Tunnel on a Curve.

Air Lock in Canal Street Connection.

The material encountered in driving the tunnel varied greatly. The connection at Canal St. was driven through a stratum of dry, coarse torpedo sand that was compacted closely and stood fairly well in most cases at the face in the heading. This sand continued in the tunnel to the west from the connection until the grade of the tunnel was raised 5 ft. to get above it. It also continued to the east from the connection, but as the tunnel grade had to be kept down in order to get under the river, the excavation had to be carried through it until it ran out about 500 ft. from the shaft connection. The mining work could be carried forward only 4 to 6 ft. at a time in this sand before the concrete lining would have to be placed, resulting in considerable delay in the progress of the work.

After the tunnel grade was raised above the stratum of sand to the west of the Canal St. shaft connection, the material encountered was largely all stiff blue clay which could be mined readily and would stand well without shoring. East from that connection after passing through the sand, and in both directions from the connection with the Clark St. shaft the soil to be removed varied from sandy loam to different kinds of blue clay, with occasional pockets of sand similar to that in the stratum passed through near Canal St. The mining was done by hand in the usual manner in all the headings, no explosives being employed. The excavated material was loaded in ½-yd. cars and hauled by mules to the mouth of the shafts on an 18-in. track laid in the bottom of the tunnel. An electrically operated Otis freight elevator installed in each of the shafts raised the cars to the surface, where they were dumped into wagons in which the material was hauled out and used for filling in the park site that is being reclaimed along the lake front of the business district. In most of the tunnel 14 to 16 ft. of progress were made every 24 hr. in each heading, the usual order of work being to mine for two shifts and then to place the concrete lining in what had been opened.

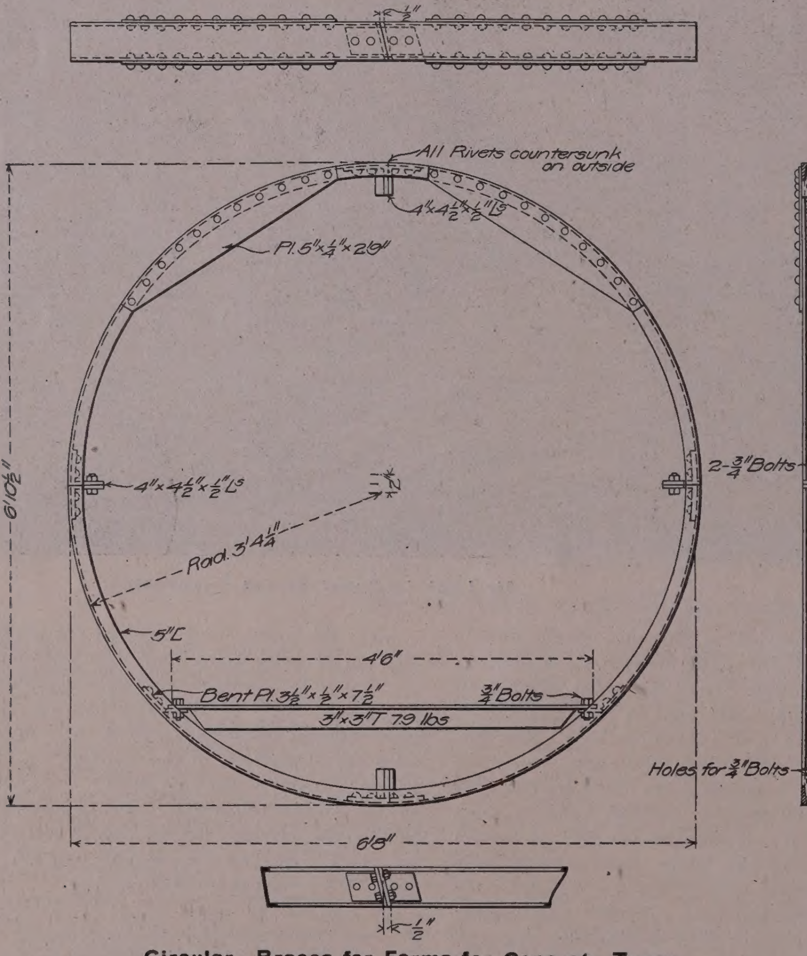
The concrete was mixed at the mouth of both shafts in a Blake concrete mixer belt-driven by an electric motor. These mixers discharge on a floor from which the concrete was shoveled into cars and lowered in the latter to the bottom of the shaft, from which it was hauled to place on the track laid on the finished work. The forms for the concrete consisted of pieces of 2x6-in. pine lagging, which were held in place by 5-in. channels bent to conform to the circle of the tunnel section, and spaced 4 ft. apart along the forms. The lagging was in 4-ft. lengths and the pieces were beveled so that they would form a true circle and also so the forms could be knocked down more readily. The circular braces made of the 5-in. channels were built in four pieces, each piece forming a quadrant of the circle. The ends of each of the four pieces had angles riveted to them in such a manner that the adjacent ends could be bolted together through holes in these angle lugs. In placing the concrete a portion of the invert of the lining, about 1½ ft. wide at the top, would first be laid the length of the excavation that had been opened. The lagging of the bottom of the form section was then laid on this concrete and the two pieces of the channel braces forming the lower half of each circular brace were bolted together and set in place. These two pieces were tied together about one-quarter the way up on them by a piece of T-iron set horizontally and bolted to them. The concrete was then carried up on each side of the portion of the invert already laid, the lagging being placed just in advance of it. When the concrete reached the springing lines of the arches the two pieces of each of the circular angle braces forming the top half of the latter were bolted together and then bolted to the lower half of the braces already in place. These two upper pieces were each strengthened by a 3/16-in. plate riveted to one leg of the channel at right angles to the lagging. The latter was laid in place as the concrete was carried up.

The forms were left in place 3 to 5 days, depending on the conditions. The construction track was laid on sleepers carried by the T-iron ties on the lower half of the circular channel braces of the forms. The absence of any centering for the forms made it possible to keep the track up to the point where mining was in progress in the heading, the cars being pushed by hand through the forms still in place, and then picked up by the mules and hauled to the foot of the shaft. The forms were very readily removed by taking out the bolts holding the pieces of the circular channel braces together, beginning at the top where the angle lugs were beveled to facilitate the removal of those pieces; the angle lugs at the bottom joint were also beveled for the same reason. These forms were found to be very economical as they could be used repeatedly with practically do damage to them and required no centering, the latter being a specially good feature as centering would have interfered with the progress of the work in advance of the forms when the latter were in place.

After the forms were removed the surface of the concrete was cleaned and then plastered with a 1:1 mortar composed of Portland cement and stone dust. One of the accompanying illustrations showing an interior view of the tunnel indicates the appearance of the concrete surface before the plastering had been done. The interstices on the surface afforded a good opportunity for bonding the concrete and the plaster coat of mortar together, the latter at the same time effectually producing a smooth uniform surface.

The line for the tunnel had to be carried down the two comparatively small construction shafts and thence in the short connections between these shafts and the tunnel to the center line of the latter where angles had to be turned in both directions. Two fine wires were plumbed down the shafts and the angles turned from these wires as a back sight. Points established in the roof of the tunnel were afterward used as backsights as the headings progressed. The line was successfully carried forward in all four headings from these short base lines, so that particularly careful work had to be done. The heading east from the Canal St. shaft connection and the one west from the Clark St. shaft connection were joined practically without error in the line. The heading west from Canal St. was carried to a 90-deg. turn at the corner of Jefferson St. and continued from the turn to a connection with a 6-ft. shaft on the old tunnel without difficulty. The heading east from Clark St. was carried straight for 820 ft. to State St., where a reverse curve with only 90 ft. of tangent between the curves had to be run in. Beyond this reverse curve was a tangent about 860 ft. long to a second reverse curve at the old tunnel connection under the lake front park. The line was successfully carried through these curves and the connection made with the old tunnel at the point projected on the plans.

The gate shaft in the lake front park is 10 ft. in diameter in the clear and 75 ft. deep, with a lining of concrete. It was sunk through filled ground and sand for a depth of 12 to 13 ft., and below that through soft clay increasing in stiffness with the depth. The excavation for the shaft was timbered throughout, but little difficulty was experienced in sinking it. The new tunnel crosses the old one at an acute angle, 40 ft. west of this shaft, and joins it again just east of the latter. The brickwork of the old tunnel was removed to permit the new tunnel to be built at the crossing, and enough of it was also removed at the junction beyond the shaft to permit the concrete section to be joined to it. The old tunnel is to be filled with sand from this gate shaft to the point where it joins the existing 5-mile cross-town tunnel from the north to the south side of the city; proposals for this work are about to be invited. The 5-mile cross-town tunnel was also built diagonally under the city, with reference to the rectangular plan of the streets. In order to avoid any difficulty with it similar to that encountered in the old tunnel under the business section of the city, a new tunnel is to be built under the streets to replace it, the proposals for contracts for this work having just been opened but not awarded as yet.

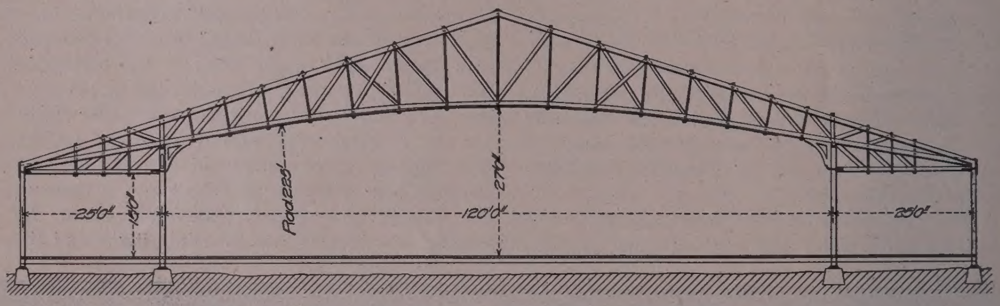


Circular Braces for Forms for Concrete Tunne

The new Polk St. tunnel was designed and built under the direction of Mr. John Ericson, city engineer of Chicago. Mr. Walter A. Shaw is engineer in charge for the city of Chicago; Mr. J. H. Spengler is assistant city engineer; Mr. H. C. Parkes was assistant engineer in immediate charge of the construction. The tunnel was built by Messrs. Jackson & Corbett, under the supervision of Mr. George W. Jackson, formerly general manager and chief engineer of the Illinois Tunnel Co.

A 170-Ft. Wooden Roof Truss.

The roof for the 170x220-ft. Coliseum skating rink and amusement pavilion in San Francisco is supported on ten transverse roof trusses 20 ft. apart on centers which, although having their main transverse supports on two rows of longitudinal interior columns 120 ft. apart, are continuous over their tops to wall columns 170 ft. apart, thus making the lengths of the trusses the full width of the building.



Wooden Roof Truss Continuous Over Side Aisles.

The trusses are 17 ft. deep over all at the center, where they are about 46 ft. high from the ground to the apex, and are about 20 ft. high above the ground at the ends. The inclined top chords are straight line rafters pitched about 1 to 3.5. The bottom chord between the intermediate columns is a segment of a circular arch with a 225-ft. radius and a 7-ft. versed sine, and between the intermediate and wall columns is straight. The center part is reinforced by a horizontal 6x5/16-in. steel plate about 100 ft. long, bolted to the lower surface. Both top and bottom chords are built up of planks bolted together and are divided into panels of 4 to 8 ft. by pairs of radial screw rods from ¾ to 1¼ in. in diameter, with upset ends and nuts bearing on washer plates on the outer surfaces of the chords.

Each panel is braced by a single diagonal strut bearing at the lower end against an angle block and at the upper end bolted between the two portions of the top chord spaced 3 in. apart, except in the third panel from the center, which is counterbraced. Each truss is seated on top of the walls and intermediate columns and is secured to the latter by curved knee braces in three directions. The extremities of the truss are secured to the wall columns by bent cover plates bolted on.

The transverse panel between the wall and intermediate columns is not obstructed by diagonals, but is stiffened laterally by a horizontal strut level with the end of the main truss and braced to it with vertical and diagonal members having the effect of increasing the depth of the truss and acting as a deep knee brace for the intermediate column, thus increasing the rigidity of the roof against lateral stresses. The trusses are braced in the planes of the intermediate columns by longitudinal trusses with end, top and bottom chords made with pairs of 3x6-in. timbers.

The alternate panels between the main trusses are also X-braced in the planes of the top chords by ⅝-in. lateral rods with upset ends and clevices attached to ⅜-in. connection plates bolted to the top chords. Some of these diagonals are continued across the intermediate panels, virtually forming two double panels of X-bracing extending across the full width of the building. Wooden purlins about 5 ft. apart on centers are fastened on the top chords by the trusses with purlin clamps and support the corrugated iron sheathing. The vertical woden columns have strap connections to cast-iron shoes anchored to concrete pedestals. The exterior of the building has a plastered finish.

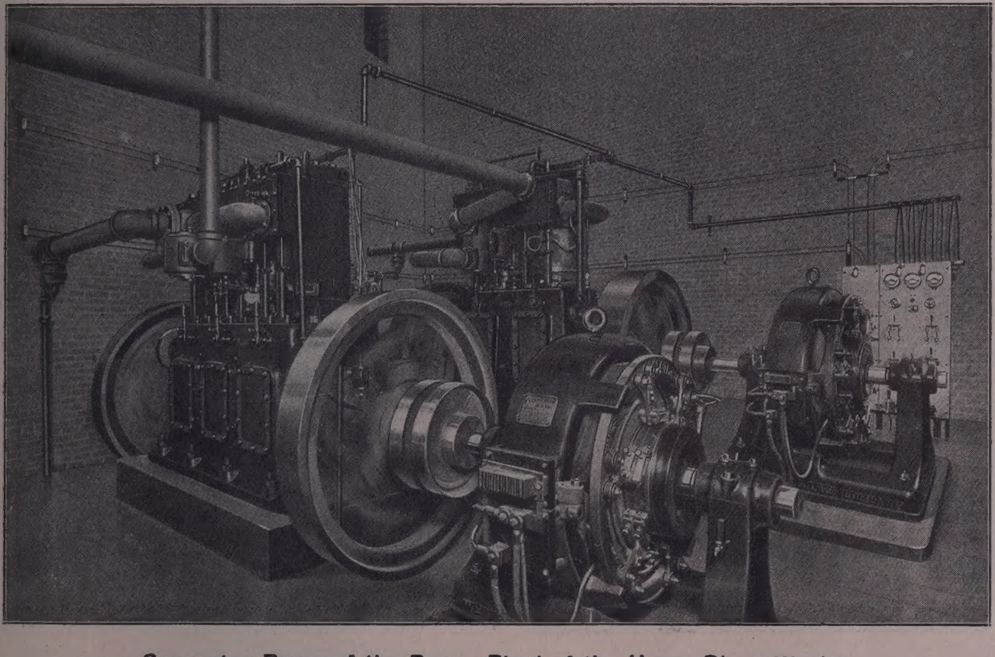
The roof is calculated for a dead load of 1½ lb. for the corrugated iron, 1½ lb. for the purlins, 7 lb. for the trusses and 10 lb. normal for wind pressure, making a total of 20 lb. per square foot of roof area. All roof timber is of Oregon pine sized and thoroughly bolted with ⅝-in. bolts. The timber is proportioned for a working load per square inch determined by the formula $1{,}200\ (1 - L/5d)$ for the compression in columns, struts and top chord; 600 lb. per square inch is allowed for compression perpendicular to the grain, 150 lb. shearing with the grain, and 1,200 lb. for tension in the bottom chord. The concrete footings are proportioned for a compression strain of 10 tons per square foot and for a bearing load of 2½ tons per square foot on the earth.

Mr. P. H. Schwerdt was the architect and Mr. J. H. Christie engineer of construction, for the San Francisco Architectural and Engineering Agency.

An Electrical Power Plant Driven by Producer-Gas Engines.

A 205-h.-p. producer-gas-engine-driven electrical power plant has recently been installed in the factory of the Home Stove Works at Eighteenth and Rockwell Sts., Chicago, the power generated by the plant being utilized in motors driving groups of machines throughout the factory. Owing to the methods employed in the latter, the total amount of power required varies continuously, normally ranging from 90 to 125 h.-p., while for considerable periods each day as much as 225 to 235 h.-p. are required. The power plant has been designed to economically provide for this fluctuating load. On the other hand, the factory is operated only 10 hr. a day, so that equipment that could be operated satisfactorily under that condition also had to be provided.

The power plant is in a triangular-shaped fireproof brick building, 30 ft. wide at one end, 7 ft. wide at the other and 85 ft. long, which occupies a site at one end of the factory next to a railroad switch yard. A transverse wall, 30 ft. from the wide end, divides the building into two rooms, one 30 ft. long at that end, for the generating equipment, and a small narrow room, 53.5 ft. long, for gas producers. The generating equipment consists of a 50-kw., 250-volt direct-current generator direct-connected to an 80-h.-p. three-cylinder vertical Weber gas engine; and an 80-kw., 250-volt direct-current generator direct-connected to a 125-h.-p., two-cylinder vertical Weber gas engine. These generators are operated in parallel. During most of the day the larger unit has sufficient capacity to carry the load, but for a few hours each afternoon the smaller unit is also required, and at times when both units are in service the two are considerably overloaded for short periods.



Generator Room of the Power Plant of the Home Stove Works.

Each engine is provided with gas from a separate Weber suction gas producer plant installed in the producer room. These plants each consist of a producer, a scrubber and a receiver, all seated on the same concrete base. The producer is a vertical cylinder built of steel plates and lined with fire brick. The coal for the producer is fed, at any time during the operation of the plant, through an automatically sealed opening in the top, the fire being on grates in the base. Four doors spaced equally around the latter provide for the removal of ashes from beneath the grate, while the fire may be stoked through a small opening in each of these doors that is closed by a hinged flap cover. The two producers are set with a passageway between them and have an iron platform built around their tops and supported by their shells. This platform is reached from the floor by a flight of steps and from it the feeding of coal is regulated. The coal is stored over the producer room in a compartment which has a concrete floor carried by steel beams, and will hold about four cars of coal. A small bucket elevator at the narrow end of the room is at present used in elevating to this compartment the anthracite pea coal used, but the grade of the railroad tracks along the side of the building is to be raised and then coal can be shoveled from the cars directly into the compartment. A steel-plate hopper is built in the floor over each of the producers and supplies a second hopper connected into the top of the latter. The hoppers on top of the producers are each fitted at the bottom with a cylindrical pocket feeding gate which is operated from the platform by a hand lever and insures at all times a tight joint preventing the escape of gas.

The hot gases are drawn by the suction of the engine from near the top of the producer into a small water jacketed boiler in which steam is generated, without pressure, by the hot gases passing to the scrubber. This steam is introduced into the bottom of the producer where it is mixed with air and supplies the hydrogen necessary in the production of gas from coal. In this manner the boiler serves to reduce the temperature of the gas and to supply steam for gas-making purposes without loss of heat.

The gas passes from the boiler into the bottom of the scrubber, which is a vertical cylinder built of steel plates and filled with coke. The gas passes up through this coke, upon which a spray of water is constantly played from the top, the water being drawn off through an overflow placed far enough above the bottom so a water seal is formed over the latter. Such heavy particles of ash as may be carried over from the producer are precipitated in the water seal and the gas is cleansed and its temperature reduced to the proper point in passing upward through the coke and spray of water. The scrubber delivers the cleansed and cooled gas to a vertical cylindrical receiver built of steel plates, which has sufficient capacity only to act as an equalizer on the supply pipe between the scrubber and the engine.

The gas is generated only as it is called for by the engine, as the entire apparatus is air tight, no gas being stored and no power plant being required. The valve mechanism in the charging hopper and the arrangement of the doors beneath the gate permit fuel to be added or ashes removed without interfering with the operation of the engine. An overflow from the small steam boiler and the one from the water seal of the scrubber, automatically keep the water levels at these points at the proper height, and in the latter case prevent the escape of gas.

The plant is operated entirely by one man who was a pipe fitter until he was trained to run this plant. Power being required at the factory during the day only, the producers and engines are shut down at night. A small separate air compressor driven by an electric motor, supplies the air that is necessary for a blast under the producer during a short period when the first is first being started. The motor driving this compressor can be operated on electrical power from the distribution lines of a public service company, or by a small gasoline engine, so the night watchman can start it 45 to 50 minutes before the engines are to be started. The operator can then readily have power available by the time the factory is to start, by arriving at the plant 20 to 25 minutes before that time. The producers are each provided with several small holes in the top which are spaced around a circle concentric with, and just inside the lining of the producer. These holes are ordinarily covered with hinged lugs, and are provided so the producer may be stoked through them from the top with a slash bar. This stoking rarely has to be done more than once a day. The amount of stoking required at the base of the producer depends on the amount of gas being consumed, but is never enough to require much attention.

The general features of the engines are evident from the accompanying illustrations. The engines are started, when cold, on compressed air furnished by the small separate compressor in the producer room. Their lubrication is effected entirely in the crank case by the splash system. The ignition is of the make and break type. The operation is controlled by a throttling ball governor driven by a secondary shaft, the governor acting directly on the air and gas supply pipes. The cylinders and cylinder heads are water-cooled; the valve chambers are also entirely surrounded by water, while the exhaust valves are internally cooled by flowing water. The pressure on the cooling water supply line is obtained from the city mains. The heated water discharged from the water jackets and so forth is conducted to a nickling room in the foundry of the factory thus effecting a considerable saving in the latter. No exhaustive operating tests have been made as yet to determine the efficiency of the installation, although such tests are to be undertaken soon. The plant was placed in regular service the last week of last year and since then has been operated on about 1½ tons of anthracite pea coal a day, with coal at $4.70 a ton delivered, including over night and Sunday losses.

The plant was designed and built by the Weber Gas & Gasoline Engine Co., of Kansas City, Mo.

Irrigation by the Igorrote Tribes in the Philippines is carried on through extended works built in the sides of the hills surrounding the narrow valleys in which they live. The slopes are so steep that terracing is necessary, and in many instances every available foot has been used. In the older districts most of terracing has been reinforced with stone retaining walls. A sort of water level made of bamboo is used in determining the location of ditches. All labor, both in building the works and farming, is performed by hand. A great variety of crops, including rice, potatoes and cotton, is grown under irrigation.

The Proposed Niagara Ship Canal.

At the present time the State of New York is engaged in the improvement of the Erie, Oswego and Champlain canals under the Barge Canal Law of 1903. The route of the Erie Canal portion begins at Congress St., Troy, and terminates on the Niagara River at the mouth of Tonawanda Creek. In order that the 1,000-ton barges may reach the harbor of Buffalo, the so-called Niagara River ship canal will be utilized. This ship canal is the culmination of a number of local improvements of the harbor of Buffalo by the United States Government, the first of which was the building of the north breakwater, which was completed in 1901. This breakwater affords protection to that part of the lake front of the city of Buffalo lying between the foot of Georgia St. and the foot of Maryland Ave.

No sooner was the breakwater completed than it was developed that to make the protected area available and to afford access to the commercial interests bordering the same, considerable dredging was necessary. This work is now in progress with the Buffalo Dredging Co. as contractor. It consists largely of submarine blasting, much of the material to be removed being solid rock, the resulting water being 23 ft. deep at mean lake level.

Following this improvement there arose a desire for a suitable channel for deep-draft vessels around the rapids and shoals at the head of the Niagara River. To avoid these it was proposed to use the so-called Black Rock Harbor to the foot of Squaw Island, and at that point enter the quiet water of Niagara River by locking down 6 ft. Lake Erie, converging at its eastern end into comparatively narrow outlines, has its outlet in the Niagara River. For a distance of 4 miles from its head the river flows through a single channel, then it is divided into two channels by Strawberry and Grand Islands. Below Grand Island the river flows through a single channel again until the great rapids and falls are reached.

The single channel of the Niagara, from Lake Erie to Strawberry Island, is narrow, swift and shallow, with rocky bed, and is exceedingly difficult to navigate. The narrow gorge and shallows at the head of the river can only be navigated by small vessels from 13 to 14 ft. draft. The velocity of the current through this portion of contracted channel is estimated at 4 to 5 miles per hour at low mean stages of the river, and 5 to 7 miles per hour at high stages of river.

Most of the river surrounding Grand Island is deep and wide, with gentle currents, and capable of accommodating the largest ships of the lakes.

The Black Rock harbor which will form the southern (western) end of the Niagara Ship Canal is in reality a canal with a wide bell-shaped upper end, built along the east bank of Niagara River and located partially between the main shore and Squaw Island. It has a lock at its lower end, 36 ft. wide by 200 ft. long between quoins, and with a depth on its miter sills of 9½ ft. at mean river level.

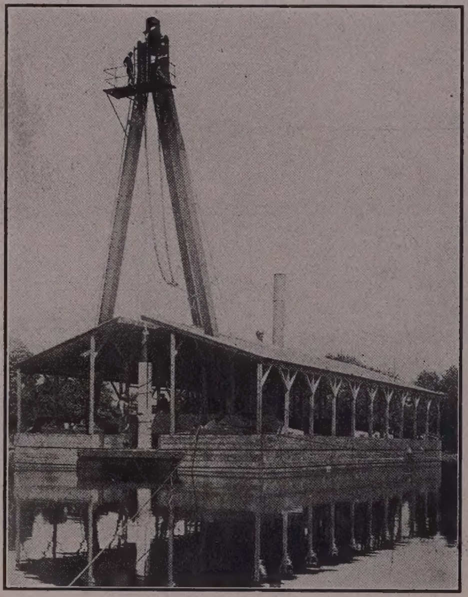
The present Erie Canal heads in Lake Erie at the mouth of Buffalo Creek and extending northward is located just inside of and adjacent to Black Rock Harbor for the entire length of the latter. The Erie Canal, in this portion of its course, originally formed a part of Black Rock Harbor, from which it is now separated by a narrow embankment or wall. At the lower end of the harbor this wall or embankment has disappeared, if it ever existed, so that the waters of the two freely mingle.

The proposed plan of improvement is to widen Black Rock Harbor to its original width by removing the wall that separates it from the Erie Canal, which once formed a part of it, thus making it from 250 to 500 ft. wide, instead of 125 ft. as at present. The resulting waterway is then to be deepened sufficiently to accommodate the largest vessels of the lakes, with a lock at its downstream end sufficient to overcome the fall of the river.

In addition the Niagara River would have to be deepened for a distance of about 2½ miles below the proposed lock, the present depth in this stretch now ranging from 18 to 20 ft. at mean river level.

The project is known officially as the Improvement of Black Rock Harbor and Channel, New York, and bids for the first 6,400 ft., more or less, of the channel were received Jan. 15, 1906, by the U. S. Engineer Office, Buffalo. The lowest bidder was the Empire Engineering Corporation of New York, and a contract was made with that company on Feb. 1, 1906.

The following are the prices paid this company: Removing material overlying hard rock, 33 cents per cubic yard, place measure; removing bed rock, $1.85 per cubic yard place measure; removing partition wall, $9 per linear foot; handling rock with derrick, 90 cents per ton. The estimated amount of material to be excavated is 530,788 cu. yd., place measure, of which 261,055 cu. yd. or approximately 49 per cent. is sand, mud, clay, gravel, etc., and 269,733 cu. yd. or approximately 51 per cent., is bed rock, the estimate being based on a length of channel of 6,050 ft. This channel to be excavated to the depth of 23 ft. at mean lake level, 200 to 240 ft. wide at the bottom, except a section 500 ft. long, which will be 100 ft. wide.



Lobnitz Cutter on Champlain Canal.

One of the interesting features of this work will be that the Empire Engineering Corporation, of which Mr. Lindon W. Bates is president, intends to use a Lobnitz rock cutter, with which to break up the bed rock, which is a decided innovation on the Great Lakes. The usual method employed by the contractors on the inland seas is to drill and blast the rock, so that the operations of the new machine will be watched with interest by all concerned in deep-water submarine excavation.

The rock cutter which is to be employed in the Black Rock Harbor and Channel was especially designed for this work by Mr. F. W. Allan, engineer for the Empire Engineering Corporation. The hull is composite, being composed of two separate hulls, each 96 ft. long and 17 ft. beam, which are fastened together by screw clamps, forming one hull 96 ft. long and 34 ft. beam when in service. The hull draws about 3 ft. 6 in. in the water when fully loaded, and the rock cutter is ready for operation. The object of building the hull in two parts is to allow each hull to pass the locks of the present Erie Canal, in case the rock cutter should be dismantled for shipment to other points.

The essential part of the rock cutter, of course, is the cutter, which was made by the Bethlehem Steel Co., Pennsylvania. It is a steel cylinder, 28 in. diameter, about 25 ft. long and weighing 46,000 lb. It is fitted at the lower end with a hardened steel conical-shaped point, resembling the end of a projectile. At the upper end there is an eye to which a steel cable is attached, leading from a very powerful steam winch of special design, built by the Lobnitz Co., of Renfrew, Scotland.

The hull is maneuvered by a six-drum steam Mundy hoisting engine, by means of six ¾-in. wire cables, each 1,000 ft. long. One of these leads forward from the bow, one aft from the stern, and one each from the four corners to port and starboard. The anchor cables pass from the drums through the deck sheaves, and run out from the deck level to the anchors, previously placed in position. After the machine has been placed, the steel cylinder is raised by the hoisting winch, and then let fall onto the bed rock. This operation is repeated until the desired result is achieved. The hull is then moved to a new position by taking in the cables on one side and paying them out in the opposite one, after which the rock crusher is raised and let fall, and so on.

Steam is furnished by a large locomotive boiler. The machine is also supplied with an electric plant and searchlight for night work. The photograph shows the general construction of the machine, the hull, the house enclosing the machinery, the A-frame supporting the rock cutter, the stack from the boiler and the searchlight.

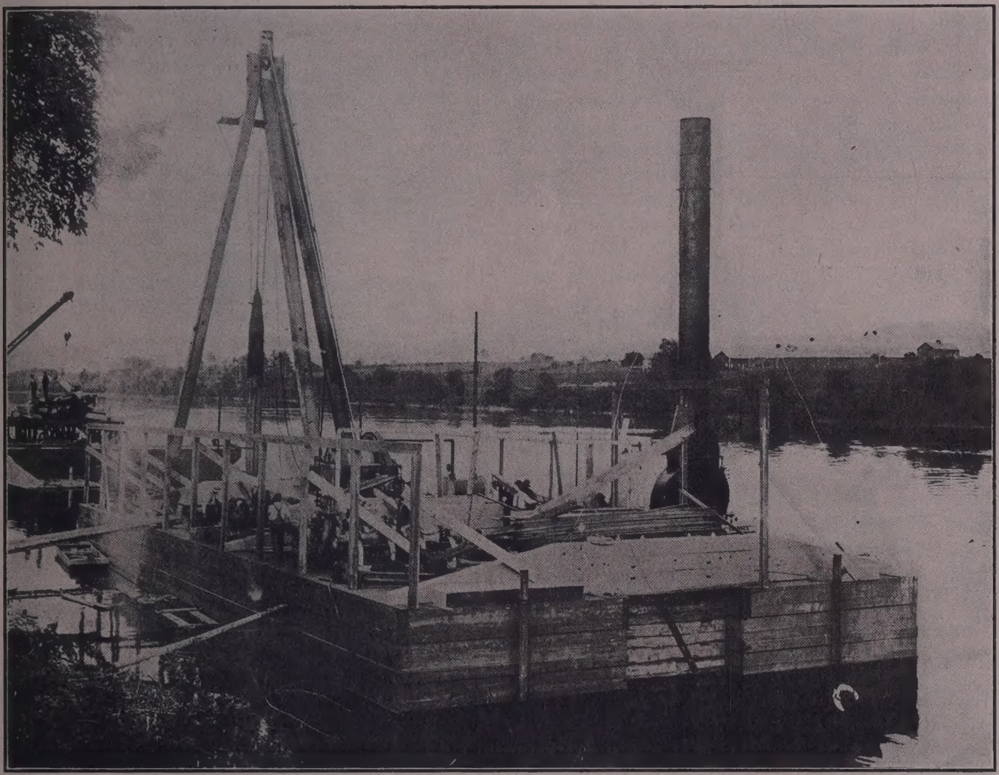
The Work of the Pennsylvania Water Supply Commission.

Since the organization, on July 3, 1905, of the Pennsylvania Water Supply Commission, 88 applications for the incorporation of water companies have been received, of which 37 have been approved, 9 disapproved, 20 are being investigated, and 2 were withdrawn. Each of these applications demanded detailed examination and included consideration of the equitable distribution of the water supplies for the several localities. Special investigations, covering obstructions to river channels, various forms of trades waste pollution, the distribution and extent of the use of the streams for water power generation, and notable cases of diversion of water from its natural channel, have also been made.

The Commission has obtained many valuable data necessary to advise it of the condition of the water supplies of the State; a library of over 400 volumes has been collected, and the information therein indexed and studied; numerous maps and blue prints relating to the streams of the State have also been secured and examined. In the course of its investigations it has examined a number of problems of public policy regarding water supplies, which are reviewed in a report recently made public, from which the following notes are taken.

The third section of the act creating the Commission provides: "It shall be the duty of the Commission to procure, as speedily as may be, all the data and facts necessary to advise it thoroughly of the situation of the water supply of the State, and adopt such ways and means of utilizing, conserving, purifying and distributing such water supplies in such a way that the various communities of the State shall be fairly and equitably dealt with in such distribution."

In compliance with these requirements the Commission has resorted to every available source of information, including an examination of the work done by the various Departments of the United States Government in this State, of the systems of canals and waterways in Pennsylvania, abandoned and in use, and of the water works throughout the State. Information was obtained from water and water power companies and municipalities, and from special investigations by the Commission of various subjects, among which are rainfall, stream flow, river stage records, floods and droughts, river profiles, forests, water power, water transportation, mineral springs, the equitable distribution, and the conservation and development of the water supplies. Details of the above and other features will be treated in special bulletins prepared for the use of the people of the State; the Commission is also collecting specific data for descriptions of the various streams of the Commonwealth.



Lobnitz Rock Cutter Being Assembled on Contract 1, Champlain Canal.

The seventh section of the act directs: "It shall be the further duty of the said Commission to collect such information relative to the existing conditions of the water supply of the State, and to make an annual report to the Governor and the Legislature, based upon such investigation, recommending such future legislation as in its opinion is necessary for the conservation, development, purification, equitable distribution, and supply of the waters of the State, and in particular to such communities as are now greatly in need of extended facilities for this purpose."

The Commission is now making a thorough and comprehensive study of the water supply of Pennsylvania, especially with respect to the following: 1, Its natural condition. 2, As affected by population and manufactures. 3, As affected by appropriation for municipal and domestic purposes. 4, As affected by appropriation for water power and for transportation. 5, As affected by obstructions to water courses. 6, As affected by forest cover, rainfall, floods, geology and topography.

Equitable Distribution.—The evident object of the act creating this Commission was to confer upon a public body authority to preserve and equitably distribute the water supplies of the Commonwealth for the common good of the inhabitants. It takes no account of the local distribution of the water, but goes to the source, and it is this that is to be preserved and equitably distributed. The Commission has procured data to inform it of the situation of the water supply of the State; and the fifth section of the act, prohibiting the incorporation of water companies without the approval of the Commission, has enabled it, to some extent, to control the distribution of the water supplies. The powers conferred are expressed in such general terms that it has been impossible to preserve and equitably distribute the water to the satisfaction of the Commission or as the act evidently contemplates. It is apparent that further legislation is needed.

Prior to the passage of the act, water companies were incorporated possessing the right of eminent domain in the appropriation of water supplies. Companies incorporated since do not acquire such right, but the act left undisturbed the powers of companies incorporated prior thereto, in that such companies may still exercise the right. This power has been exercised, in some instances, without due regard to the present and future needs of others having a like or greater claim to the water supplies thus appropriated.

The use of water for domestic purposes is a natural right, and paramount to any which commerce may have to its utilization. Companies, especially those incorporated for the supply of water for commercial and manufacturing purposes, have secured some of the best streams of the Commonwealth, which, if not needed at present, may be required in the near future by individuals and communities for personal and domestic use. It is probable that the development of some localities will depend in a great measure upon the solution of the problem of securing a satisfactory water supply, and it is to the interests of commerce that individuals and communities be fully supplied. Commercial water companies have not only appropriated water from the rivers, where it is abundant, but have taken the streams flowing from the hills and mountains, which are the natural supplies, present and future, for communities, boroughs and cities. Commerce must finally recognize the superior claims of individuals and communities to the pure flowing streams of the Commonwealth, and seek most of its supplies in the abundant waters of the rivers.

These observations apply to water and transportation companies which have appropriated for commerce such water as may be considered as belonging naturally to individuals and communities. Contentions will also arise, with the increase of population, between municipalities and water companies appropriating water supplies for domestic use.

It is equally important that the rights of persons, corporations and municipalities be protected, whether against the appropriation of water for commerce or for domestic use; and the rights of commerce, manufacture, transportation, individuals and communities are all entitled to consideration, and should be fully protected, for the water supply of the State is sufficient for every demand, if properly conserved and fairly distributed.

Authority should be conferred upon the Commission, it states, to enable it to do effective work in the equitable distribution of the water supply of the State; and, to this end it recommends legislation subjecting water and other companies, owning or controlling water or water power, to the control of the Commission, and authorizing it to limit, restrict and control such companies, both as to the source of their water supplies and the amount appropriated, when, in its judgment, the necessities of individuals, communities and other water companies may require such water supplies for personal or domestic use, or for sanitary or fire purposes. This would enable the Commission, in case of necessity, after hearing the parties interested, to remedy the injury done; and provision should be made requiring the consent of the Commission to the acquisition of any water supply or any new or additional water supply. The powers thus conferred should be so guarded that no injury may be done to any interest affected by the action of the Commission.

The act of 1874 and amendments thereto, authorize water companies to "appropriate so much of the water from rivers, creeks, canals, water rights and easements as may be necessary for their corporate purposes." The act does not take into account that in such appropriation persons and communities may be deprived of a water supply, or that commerce may be served to the detriment of the individual, or that the natural rights of the people may be disregarded. The law contemplates that the water supply is abundant and to spare, and yet it has so happened that by the lawful exercise of corporate powers, the water supplies needed for present or future use by persons and communities might be appropriated for purposes of commerce, a result not foreseen. A law such as heretofore suggested, would enable the Commission to do justice to all interests, and its enactment would be but an exercise of the police powers of the State for the common good, in the Commission's opinion.

If the power be not reserved in the grant, the State cannot repeal a charter unless the business for which the company was incorporated proves injurious, or against public policy; but it may prohibit the transaction of such business absolutely, or save under certain conditions, and the company must conform to the general rule. The police power is thus a corrective to the ill consequences which might ensue from the doctrine that statutory grants are contracts and cannot be altered or repealed. And, furthermore, as many of the water companies now operating were created under the Act of 1874, such companies are subject to the provision of the Constitution of the State, which confers upon the General Assembly "the power to alter, revoke or annul any charter of incorporation whenever in their opinion it may be injurious to the citizens of this Commonwealth."

Obstructions of Channels.—Complaint has been made to the Commission relative to encroachments upon rivers by the construction of walls, banks and dams; also that the current and course of streams have been changed, and the channels of rivers diminished by depositing cinder, slag, earth, and the like in them. The Commission is unable to control such matters, or give relief, by reason of an apparent want of power under the act. Doubtless some of the deficiencies might be corrected, under certain conditions, to the advantage of all concerned; but such work should be under definite regulation and control of public authority, and have the sanction and oversight of the Commonwealth.

The Commission recommends legislation providing that hereafter no wharf, dam, wall, embankment or other obstruction shall be constructed along or in the rivers or streams of this Commonwealth, nor shall the course, current or cross section thereof be changed or diminished until maps and plans thereof, and such other information and authentic data relating thereto as the Commission may require, are first submitted to the Commission, and until after considering the application and protests, if any, it shall approve of the same. This would enable the Commission to require that such improvements and works be made to conform both to the present and future interests of the Commonwealth; the intent being to control rather than prohibit alterations to the courses or channels of streams.

Influence of Forests.—A study of the flow of the streams of Pennsylvania shows that, generally, they are becoming more irregular, primarily the result of forest destruction. That the flow is made irregular by deforestation is sufficient to indicate the importance of forest protection, for the dry weather flow often determines the value of a stream as a water resource, and this dry weather flow is seriously influenced by deforestation.

In March, 1894, the Pennsylvania Forestry Commission sent a list of questions to all counties in the State, in the endeavor to determine local opinion upon the question of decreased low water flow and its cause. The replies may not have been the scientific judgment of men trained in the study of forestry and of stream flow, but their general agreement has great significance. One hundred and seventy-four replies to these questions, covering fifty-eight counties in the State, have been tabulated.

In answer to the question: "Name and locate stream or streams in which you know there has been a change in quantity of water carried," 174 replies were received; these named 127 streams, and qualified the reply to show that there was a reduction which was considered due largely to the decrease of forest areas. Three replies stated that the streams were improving, and twelve reported no change.

Although these data are of uncertain value, being largely based on impression and hearsay, they indicate that twelve years ago the agency of the forests in regulating stream flow was generally understood and appreciated, and that there has been a widespread and detrimental influence upon the flow of the streams of Pennsylvania.

In the investigation by the Commission the question was asked of water power users throughout the State, whether or not streams were deteriorating as water power producers. Of the 343 replies received, 113 stated that the stream used was deteriorating, 109 that there was no perceptible change, and 26 that the stream was improving. These questions, dated twelve years later than those of the Forestry Commission, indicate existing conditions, but in parts of the State deforestation was practically complete many years ago, and in all probability the experience of parties answering did not extend to the period preceding the forest destruction. Doubtless many streams of Pennsylvania reached the deterioration, caused by deforestation of their drainage areas, years before the experience of those who replied to the inquiry, and have practically continued to show a low efficiency in dry seasons.

Recognizing this influence on the character and quantity of the run-off in streams, this Commission has obtained, whenever possible, reliable information concerning the location of the forest covered areas in the State, and has secured, through Henry Gannett, Chief Geographer of the United States Geological Survey, a set of the completed quadrangles in Pennsylvania, upon which these forest areas have been plotted. This has made it possible to determine the percentage of certain drainage areas which are forest covered. Owing to the fact that only about one-third of the area of the State has been mapped as yet, such data are fragmentary.

The commission heartily endorses the work of the Forestry Reservation Commission of Pennsylvania in establishing and cultivating State forest reserves, and providing instruction in scientific methods of lumbering and forest culture. Although the State owns approximately 800,000 acres of forest lands, the Commission recommends further purchases and increased protection of forests, especially along the headwaters of important rivers and streams. Such areas form great natural storage which may modify the severity of floods, and aid in maintaining a more uniform dry weather flow of streams.

Reservoirs.—In some States part of the excess water, resulting from heavy downpours and rapidly melting snow, is impounded in large storage reservoirs, and released in times of scarcity, under the direction of State authorities, to supplement low stages of the rivers and streams, for the use of the inhabitants. A similar policy is worthy of the consideration of the Legislature. The construction by the State of impounding reservoirs, available to localities likely to suffer from severe droughts, would be considered a measure in the interest of the health and lives of the inhabitants, upon the same principle that municipalities are authorized by the State to build works to supply their citizens with water. Such reservoirs, if of sufficient magnitude, may, to some extent, be protection against floods and, at the same time, conserve the water supplies, especially if located in or subject to the drainage from forest reservations.

Water Powers.—The laws of this Commonwealth should encourage, the Commission holds, the development of water power for industries and for the generation of electricity for commercial, manufacturing and domestic purposes. Two acts of the Legislature were passed July 2, 1895, with this object in view. The first provided:

"Corporations organized, or hereafter to be organized, under the laws of this State, for the purpose of supplying water power to the public, and other corporations owning or controlling water power, may develop electric power for commercial purposes by means of water power, and shall have authority to supply current and power to the public, individuals, firms and corporations, at such prices as may be agreed upon, and shall have authority to make, erect and maintain the necessary buildings, machinery and apparatus for developing power and current, and to distribute the same to any place or places."

The second provided:

"Corporations heretofore or hereafter incorporated under the Acts of Assembly, entitled 'An Act to provide for the incorporation and regulation of certain corporations,' approved April 29, 1874, and the supplements thereto, for the supply, storage and transportation of water and water power for commercial and manufacturing purposes, be and the same are hereby authorized and empowered to determine the character, design and construction of the works and the use to be made of the water and water power of such companies, in order that the same may be supplied to the public to the best advantage."

These acts are inadequate for the proper development of the water power of this State, in the opinion of the Commission, which reports that laws should be enacted conferring upon water power companies privileges commensurate with the importance of the undertakings, defining these powers in clear terms, and authorizing the development of water power from the streams of the Commonwealth for the generating of electricity, and to supply current at any place in the Commonwealth to the public, persons, partnerships, corporations and municipalities, for commercial manufacturing and domestic purposes. The law should require the charter to state where and how the water power is to be secured and furnished, and where the electric current is to be supplied so that the company will be obliged to furnish, under equitable terms, such power and current in the territory named, with a provision authorizing amendments to the charter so as to include additional territory. Such corporations, by reason of their magnitude and by reason of the fact that in many cases there is no competition, should be under the control of the State.

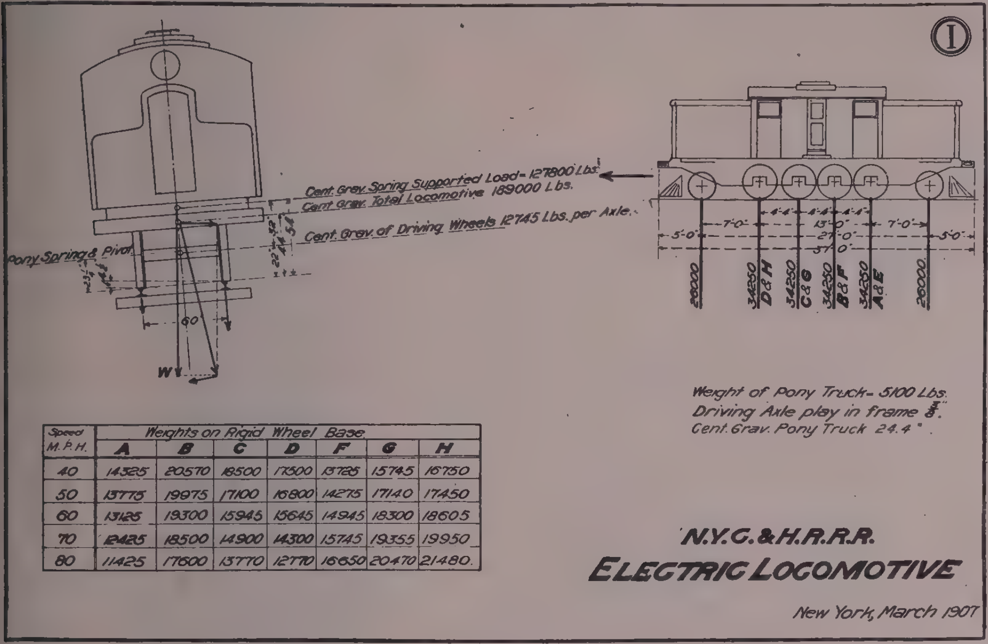
The Teltow Canal Tractors.

The electric tractors used on the Teltow Canal in Germany for hauling the barges, which are exceptionally heavy, are 6-wheel electric locomotives running on a track of one-meter gauge. The locomotive has a 4-wheel main truck and a pair of trailing wheels to give stability when a towing mast is used. Each axle of the main truck is driven through double-reduction gearing by an 8-h.-p., 550-volt motor. The towing mast can be raised or lowered by a 3-h.-p. motor, and when it is raised the steel wire towing rope, which is about 0.4 in. in diameter, is carried about 12 ft. 4 in. above the level of the rails, and can easily clear any barges lying by the canal banks. As the pull on the tow-rope is oblique, and tends to tilt the locomotive backwards, and sideways towards the canal, the main weight of the locomotive is concentrated as much as possible forwards and on the landward side. The locomotive has an average speed of 2.6 m. p. h., and is normally capable of exerting a pull of 1.2 tons. A heavy barge at starting may, however, require a pull of about 2 tons, and in order to prevent any overload on the locomotive the following arrangement has been adopted. The end of the tow-rope is not rigidly fastened to the locomotive, but is wound on a drum which may be driven by a 3-h.-p. motor running at 1,460 r. p. m. The drum is not keyed to its shaft, but is attached to it through a friction clutch made up of a number of plates which may be pressed together more or less tightly. The clutch is so adjusted that it begins to slip, and allows the rope to run out, when the pull exceeds 1.2 tons. Where the canal passes through lakes, the barges are hauled by a tug-boat driven by a secondary battery. The overhead wire supplying the locomotives with current is of figure-eight section.

The Highways of Pennsylvania have a length of 99,777 miles, according to figures collected by the Office of Public Roads. Nine miles have been surfaced with stone under the direction of the State Highway Department, 1,051 miles have been so surfaced by various counties and townships, and 1,101 miles have been more or less improved with stone or gravel by Turnpike companies. There are 2.21 miles of road per square mile and 1 mile of road for every 63 inhabitants.

Centrifugal Force on Curves and Its Resistance by Track.

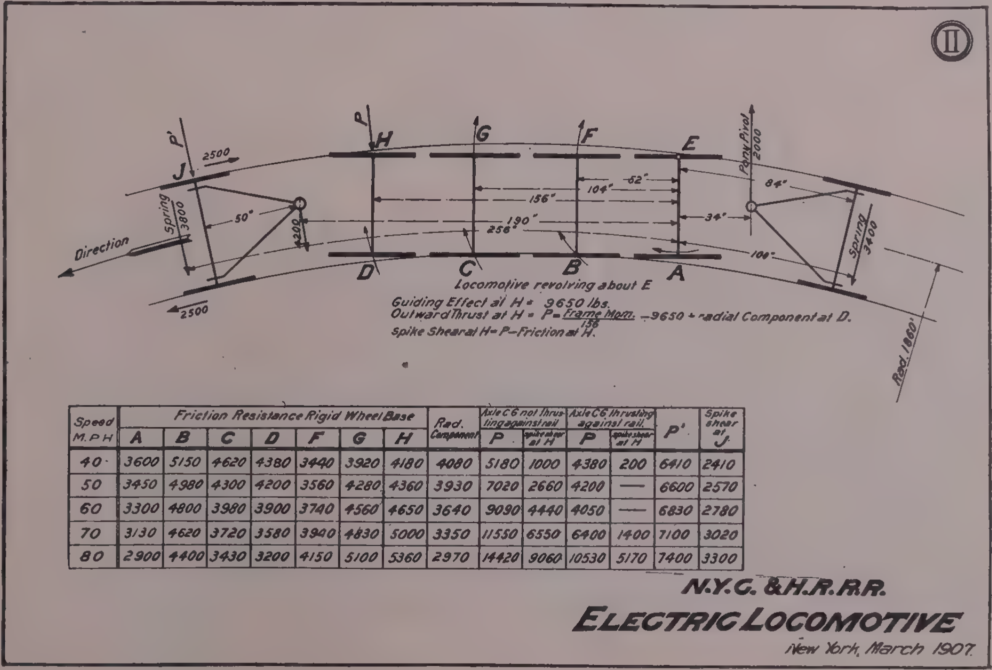
The general problem of track strength on curves has long been regarded as one of great complexity. While it is possible to compute with considerable accuracy the total centrifugal force of a locomotive while rounding a curve and the effect of the superelevation of the outer rail, there is a marked difference of opinion regarding the pressures between the wheels and the rails which cause the skewing of the locomotive wheel base. Many years ago the late A. M. Wellington published in his "Economic Theory of Railway Location" a general statement of the mechanical principles involved in this problem, but the application of those principles requires so many assumptions that engineers have differed materially in their computations of this wheel-rail pressure. The problem has been receiving renewed attention lately on account of the accident a short time ago on the New York Central lines, when some of the cars of a train drawn by an electric locomotive left the track on a curve and were overturned, resulting in serious loss of life. It was found that spikes holding the outer rail in place had apparently been sheared off, and various statements have been made that the special design of the electric locomotive probably produced this shearing action. It should be pointed out that even if the electric locomotive did the shearing it did not leave the track, nor did the car following it, and a good deal of doubt has been expressed that a pressure could be strong enough to shear the spikes and spread the rails without derailing the locomotive and the following car. It is also of interest in this connection to recall the fact that when the first of these electric locomotives was tested on an experimental track near Schenectady, it was purposely driven at a speed of 75 miles an hour around a curve elevated for but 60 miles in order to accentuate any tendency of the locomotive to spread the gauge. At this speed the ties were moved in the ballast, but there was no widening of the gauge. This track was purposely of a type inferior to that in the New York Electric Zone, where the accident occurred, as the engineers engaged in the test desired to observe by the action of this experimental track just what effect the electric locomotives had on ties, rails and fastenings.


I
Cent. Grav. Spring Supported Load = 127800 Lbs.
Cent. Grav. Total Locomotive 189000 Lbs.
Cent. Grav. of Driving Wheels 12745 Lbs. per Axle.
Pony Spring & Pivot
60
W
7'-0"
4'-4" 4'-4" 4'-4"
13'-0"
7'-0"
5'-0"
27'-0"
5'-0"
37'-0"
26000
34250 D&H
34250 C&G
34250 B&F
34250 A&E
26000
Weight of Pony Truck - 5100 Lbs.
Driving Axle play in frame ⅜".
Cent. Grav. Pony Truck 24.4".
N.Y.C.&H.R.R.R.
ELECTRIC LOCOMOTIVE
New York, March 1907

Speed M.P.H.	Weights on Rigid Wheel Base						
	A	B	C	D	F	G	H
40	14325	20570	18500	17500	13725	15745	16750
50	13775	19975	17100	16800	14275	17140	17450
60	13125	19300	15945	15645	14945	18300	18605
70	12425	18500	14900	14300	15745	19355	19950
80	11425	17600	13770	12770	16650	20470	21480.

Computed Wheel Loads at Different Speeds, Electric Locomotive.

Since the accident occurred the engineers of the New York Central lines, the General Electric Co. and the American Locomotive Co. have been making a careful examination of the general problem of wheel rail pressures on curves and have reached some conclusions in which it is understood that Professors Swain and Allen, of the Massachusetts Institute of Technology, agree. The general system of analysis adopted is shown in the accompanying diagrams, reproduced by permission of the New York Central authorities. It is an elaboration of that given on pages 281-301 of Mr. Wellington's well-known treatise, where the leading principles are discussed so fully that it is unnecessary to go into them here in detail. In general they are based on three forces: (1) that producing slipping in the direction of the radius of the curved track and due to curvature; (2) that producing slipping along the rails and due to the difference in length between the inner and outer rails on curves; (3) the resultant of the centrifugal force of the locomotive and the effect of the superelevation of the outer rail on curves.


II
P'
2500
J
Spring 3800
50"
200
Direction
2500
P
H
G
F
E
Pony Pivot 2000
52"
104"
156"
190"
256"
34"
84"
100"
Spring 3400
D
C
B
A
Rad. 1860'
Locomotive revolving about E
Guiding Effect at H = 9650 lbs.
Outward Thrust at H = P = Frame Mom./156 − 9650 + radial Component at D.
Spike Shear at H = P − Friction at H.
N.Y.C.&H.R.R.R.
ELECTRIC LOCOMOTIVE
New York, March 1907.

Speed M.P.H	Friction Resistance Rigid Wheel Base							Rad. Component	Axle C G not thrusting against rail		Axle C G thrusting against rail.		P'	Spike shear at J
	A	B	C	D	F	G	H		P	spike shear at H	P	spike shear at H		
40	3600	5150	4620	4380	3440	3920	4180	4080	5180	1000	4380	200	6410	2410
50	3450	4980	4300	4200	3560	4280	4360	3930	7020	2660	4200	—	6600	2570
60	3300	4800	3980	3900	3740	4560	4650	3640	9090	4440	4050	—	6830	2780
70	3130	4620	3720	3580	3940	4830	5000	3350	11550	6550	6400	1400	7100	3020
80	2900	4400	3430	3200	4150	5100	5360	2970	14420	9060	10530	5170	7400	3300

Wheel-Rail Lateral Pressures and Spike Shears, Electric Locomotive.

This diagram was reproduced from an early and incomplete sheet and the figures in the tenth, eleventh, twelfth and thirteenth columns should be changed to read as follows:

Speed, miles per hour	40	50	60	70	80
P, axle *G C* not thrusting against rail	4,740	7,400	10,470	14,130	18,360
Spike shear at *H*, same conditions	560	3,040	5,820	9,130	13,000
P, axle *G C* thrusting against rail	3,860	4,120	4,480	7,460	11,000
Spike shear at *H*, same conditions	....	....	....	2,460	5,640
Centrifugal effect at *H*	—1,590	1,320	4,880	9,050	13,790

The radial slip of the front outside driver is considered in this analysis to take care of itself without appreciable tendency to displace the rail, but the radial slip of the front inner driver acts through the axle to force the flange of the outside driver against the outside rail. Furthermore, where the clearance between the driving wheel hubs and the locomotive frame is not great enough to allow the flange of the outer second driver to bear against the rail, the frame of the locomotive has to carry the radial slippage of the second set of drivers.

The analysis of curve resistance was worked out by the engineers for a 3-deg. curve with 4½-in. superelevation, which was used at the place of the accident, for the electric locomotive and also for the New York Central's Atlantic type of steam locomotive. The latter was chosen because it produced more severe effects of the class under investigation than any other type of passenger locomotive permissible on the Harlem division. Any other type, it is believed, would have given results more favorable to the electric locomotive.

Two conditions were studied, the first where the radial thrust of the second pair of drivers is transmitted through the frame to the front outer driver, and the second where the second driving axle has enough end play to allow the flange of the second outer driver to bear directly against the outer rail.

First Condition.—The computations by the engineers of the three companies show that the pressure against the rail of the leading driver is greater in all cases with the steam locomotive than with the electric locomotive, but the resultant shear on the spikes is less on account of the higher center of gravity of the former type.

With the electric locomotive the shear on the spikes due to the guiding truck is in excess of that due to the drivers up to a speed of about 40 miles an hour, while with the steam locomotive this is true up to about 65 miles.

The pressure of the front outer driver on the rail is greater in all cases with the steam locomotive than with the electric locomotive. The resultant shear on the spikes, however, is less with the steam locomotive up to speeds of about 80 miles an hour, on account of the influence of its higher center of gravity.

Second Condition.—In this case the shear on the spikes with the electric locomotive is greatest at the guiding truck up to speeds of about 75 miles an hour. With the steam locomotive the shear due to the guiding truck is greatest at all speeds, and exceeds that of either the drivers or truck wheels of the electric locomotive at speeds up to 75 miles an hour.

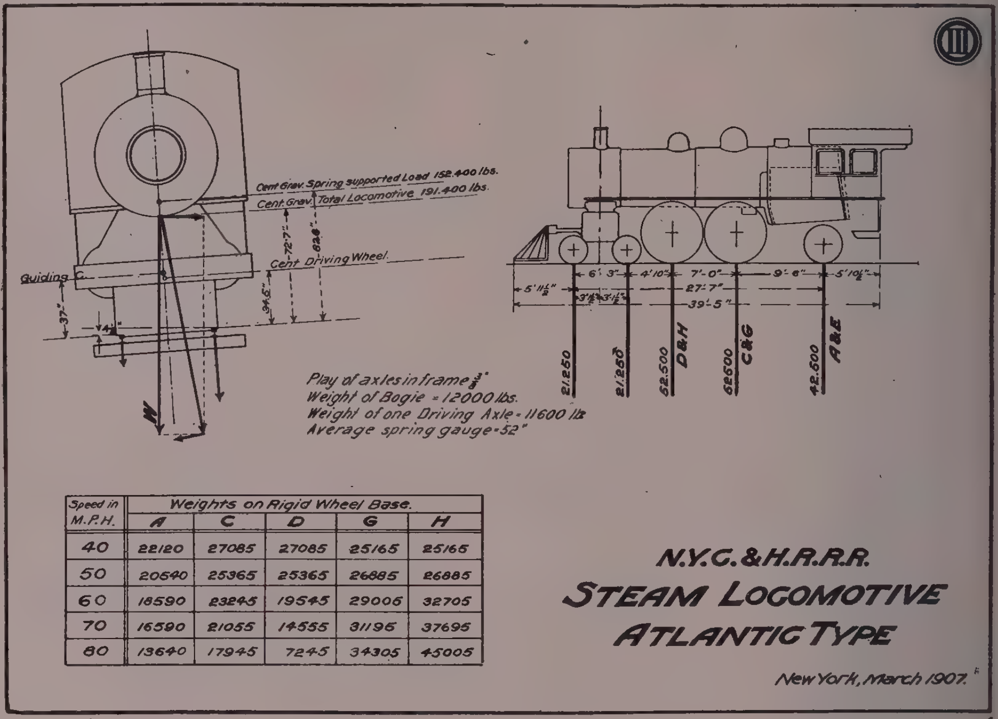
The computations indicate that under the first condition the maximum shear on the spikes produced at different speeds by the two types of locomotives on the curve in question varies as follows:

Speed, miles..	40	50	60	70	80
Elec. loco....	2,410	3,040	5,820	9,120	13,000
Steam loco...	4,630	4,740	4,890	5,970	9,910

As a matter of fact the conditions on this curve were such that the outward thrust of the second driving axle would be carried by the flange of its outer wheel and the resultant maximum shear which actually occurred was less with electric locomotives up to and including 70 miles per hour. Computations indicate that under the second condition the maximum shear on the spikes produced by the two types of locomotives on the curve in question varies as follows:

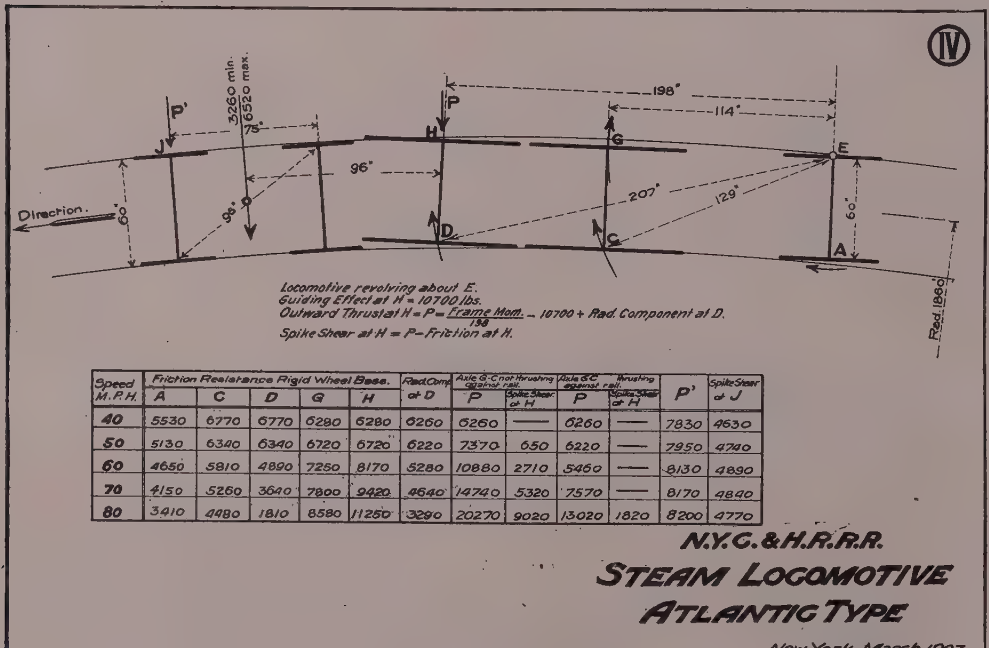
Speed miles...	40	50	60	70	80
Elec. loco.....	2,410	2,570	2,780	3,020	5,640
Steam loco....	4,630	4,740	4,890	4,840	4,770

The spikes used on the track have a shearing resistance of 14,400 to 17,000 lb. The engineers consider that it is proper to consider that the 100-lb. rail used on this curve distributed the outward thrust over at least two spikes, which indicates that the spikes were strong enough for their purpose. On this point Prof. Mansfield Merriman has made the following comment in a letter to Mr. G. W. Kittredge, chief engineer of the New York Central R. R.:



Speed in M.P.H.	Weights on Rigid Wheel Base.				
	A	C	D	G	H
40	22120	27085	27085	25165	25165
50	20540	25365	25365	26885	26885
60	18590	23245	19545	29006	32705
70	16590	21055	14555	31196	37695
80	13640	17945	7245	34305	45005

Computed Wheel Loads at Different Speeds, Steam Locomotive.


IV
P'
J
3260 min.
6520 max.
75"
P
H
198"
114"
G
E
96"
207"
129"
Direction
96"
D
C
A
60"
Rad. 1980'
Locomotive revolving about E.
Guiding Effect at H = 10700 lbs.
Outward Thrust at H = P = Frame Mom. / 198 — 10700 + Rad. Component at D.
Spike Shear at H = P − Friction at H.
N.Y.C.&H.R.R.R.
STEAM LOCOMOTIVE
ATLANTIC TYPE
New York, March 1907.

Speed M.P.H.	Friction Resistance Rigid Wheel Base.					Rad. Comp. at D	Axle G-C not thrusting against rail.		Axle G-C thrusting against rail.		P'	Spike Shear at J
	A	C	D	G	H		P	Spike Shear at H	P	Spike Shear at H		
40	5530	6770	6770	6280	6280	6260	6260	—	6260	—	7830	4630
50	5130	6340	6340	6720	6720	6220	7370	650	6220	—	7950	4740
60	4650	5810	4890	7250	8170	5280	10880	2710	5460	—	8130	4890
70	4150	5260	3640	7800	9420	4640	14740	5320	7570	—	8170	4840
80	3410	4480	1810	8580	11250	3290	20270	9020	13020	1820	8200	4770

Wheel-Rail Lateral Pressures and Spike Shears, Steam Locomotive.

This diagram was reproduced from one of the early and incomplete sheets and the figures in the seventh, eighth and ninth columns should be changed to read as follows:

Speed, miles per hour	40	50	60	70	80
Radial component at *D*	6.280	6,080	4,680	3,500	1,730
P, second outside driver not against rail	6,120	7,450	11,230	15,390	21,160
Spike shear at *H*, same condition	....	730	3,060	5,970	9,910
Centrifugal effect at *H*	—380	1,970	7,450	13,090	21,050

"In justification of the assumption that the pressure was distributed over two spikes, I note that all bridge specifications consider the weight of a wheel to be distributed over three ties, indicating that experience has shown this to be true. Also when tie plates are not used track specifications require rail braces to be placed against the outer rail of a 3-deg. curve on every third or fourth tie, indicating that experience has proved that the radial pressure under a wheel is distributed over at least three ties."

The Increase in Traffic during 1906 on the Pennsylvania R. R. lines east of Pittsburg and Erie, over that of two years ago, is shown by an increase in mileage of 18 per cent. for all freight cars, 12.4 per cent. for passenger equipment, and 17.8 for locomotives. The growth in freight traffic was especially large on the Pennsylvania and the Buffalo & Alleghany Valley divisions; the increase in freight equipment mileage on the latter is stated to have amounted to 33 per cent. in two years.

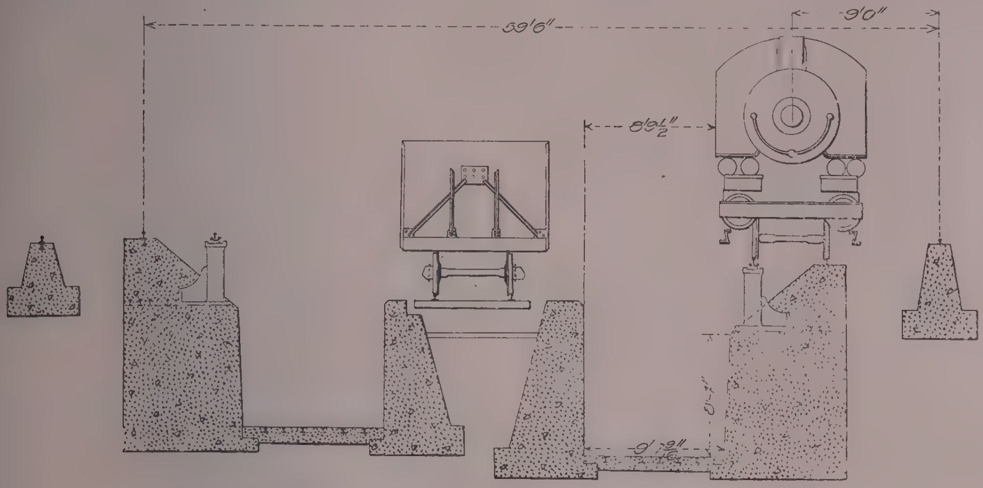
An Investigation of Creosote.

The analysis of creosote is being investigated by the U. S. Forest Service. It is believed that creosotes of different compositions have different values as wood preservatives, and consequently the investigation of the methods of analysis has become important to the progress of wood preservation. The principal part of the analysis is the fractional distillation by which the determination of the relative proportion of different constituents is made. Laboratory experiments carried on by the Forest Service show that the difference in the weights of the fractions obtained when using different sorts of distilling vessels is not large, but that the compositions of the fractions indicate a little better separation by the flask than by the retort. The investigation also includes the determination of the percentage of the various creosote constituents at all stages of the distillation, and of the specific gravity and index of refraction of the distillate. The importance of this investigation is considerable because at the present time there is a growing belief that some of the lack of uniformity in results of wood treatment may be traced to the creosote used.

The Reduction of Friction in oil pipe lines by rifling the interior of the pipe was discussed in a paper recently read before the Engineers' Society of Western Pennsylvania, by Mr. S. N. Speller, of the National Tube Co. He stated that in the oil fields in Southern California, considerable quantities of steel pipe of the pipe lines have thus been rifled, the purpose of which is to cause the viscous oil intermixed with a small percentage of water to whirl as it moves rapidly through the pipes. It is understood that when a sufficient velocity is attained a layer of water flows between the oil and the pipe, reducing the friction in the line. It has been found practicable to roll spiral corrugations, 3/32 in. deep, in the interior surface of the pipe by means of apparatus which forces a ram with six rollers or wheels, equally spaced around the circumference and slightly inclined to the axis of the pipe so as to make a complete revolution on the inner surface of the pipe every 10 ft.; the material of the pipe seems to withstand this treatment perfectly without heating.

The Ash Handling Plant of the Delaware, Lackawanna & Western R. R. at Scranton, Pa.

The new ash-handling plant, recently installed by the Delaware, Lackawanna & Western R. R., at Scranton, Pa., consists of two parallel concrete pits over each of which seven locomotives can be accommodated at once, with a track between for ash cars. A gantry crane with a clam-shell bucket is used to transfer the ashes from the pits to the cars. The new plant has proved very efficient in its operation, and frequently 300 engines are cleaned over the pits in a day, the average number being about 170. The construction required 4,304 cu. yd. of concrete, 238,770 lb. of cast-iron, and over 7,500 lin. ft. of steel rail.



Cross-Section of Ash-Pits of Lackawanna R. R. at Scranton.

The pits are 400 ft. long and are nearly rectangular in cross-section, each being 8 ft. 4 in. deep and 9 ft. 7 9/16 in. wide at the bottom, with nearly vertical sides. The engine track for each pit is placed along its outer edge, and is carried on a massive concrete foundation, which also serves as the outside wall of the pit. The elevation of the rail top of the engine tracks is 4 ft. 6 in. above the top of the pit and the ashes, falling from the fire box, slide down the surface of the concrete wall on a slope of 1 horizontal to 1½ vertical and drop into the pit. The outer rail of each locomotive track weighs 80 lb. per yard, and has its base flush with the top of the concrete wall, being held in place by bolts which attach it to the base of an inverted 80-lb. rail imbedded in the concrete. The inner rail is one of three 80-lb. rails which are securely fastened together with filler blocks and bolts forming a girder which is supported on 10-ft. centers on cast-iron posts, whose bases are deeply imbedded in the concrete wall and whose tops are provided with special clips and bolts which hold the girder securely. In the bottom of each pit railroad rails are imbedded with their heads flush with the surface of the concrete which is thus protected from being damaged by the clam-shell bucket. The corners of the concrete walls, where they are likely to be struck, are protected by imbedded railroad iron or by a special casting. The concrete walls were all built in 30-ft. sections.

The ash car track has room for eleven steel cars and rests on earth filling between the inner walls of the two pits. This fill is drained by weep holes in each wall spaced 30 ft. center to center and connected to 4-in. vitrified pipe drains. The walls enclosing this fill are tied together with old 60-lb. rails. Immediately under the ash track are two 2-in. steam pipes extending the whole length of the pit, which can be used for thawing snow or ice on the ash track. Just outside the crane rails and parallel to them is a 6-in. water main on each side of the pit. Hydrants are connected to each of these mains at 100-ft. intervals from which water can be taken to wet down ashes in the pit. During the present winter the pits have been kept quite wet, but no trouble has been occasioned by freezing since the water is kept warm by the hot ashes falling into it. When an engine is to be sent to the shop the fire box is washed out with water drawn through a hose from the nearest hydrant. At the ash pit there are water-cranes so located that an engine on either track at the pit can take water.

Gantry Crane used by Lackawanna R. R. for Ash Handling.

The gantry crane was designed and built by the John A. Roeblings Sons Co., of Trenton, N. J. It has a span of 59 ft. 6 in. and travels the entire length of the pit. The operator cab is placed on top of the cross trolley and has a lateral movement, giving the operator a good view of the bucket with the least possible trouble from steam and smoke. The 1¾-yd. clam-shell bucket opens the long way of the pit and with it 400 cu. yd. of ashes can be handled in ten hours without difficulty. The crane and bucket are operated with three 22-h.-p. General Electric alternating current motors and one 6-h.-p. alternating motor of the General Electric type. No metal less than ⅜ in. thick has been used in the steelwork of the crane. All the spur and bevel gears are steel and machine cut, and the trolley wheels and track wheels are turned cast-steel. A special clamp is provided with which the crane can be locked to the track when it is left at night to prevent its being moved by a strong wind. The crane rails weigh 80 lb. per yard, and each is supported on a continuous concrete foundation, 5 ft. wide at the base. The runway rails are attached by bolting to an inverted rail buried in the concrete.

The plant was designed by Mr. George J. Ray, division engineer, under the direction of Mr. L. Bush, chief engineer of the Delaware, Lackawanna & Western R. R., and the construction work was done by the Bridge and Building Department, under the direction of Mr. W. B. Hixson, superintendent of bridges and buildings.

Transporting a Large Steel Tank.

Moving a thirty-ton steel tank a distance of four miles around two curves with an elevation of 5 in. was recently successfully accomplished on the New Mexico division of the Atchinson, Topeka & Santa Fe Ry. The tank is 24 ft. in diameter and 43 ft. in height and is built of steel plates. It was first moved from its old site to the railroad track on rollers, then raised with jack screws to the height of a platform 24 ft. wide, which had been built on two steel-frame flat cars. The tank was anchored to the car sills with chains and braced on each side with three braces fastened to the car floor and extending out 4 ft. from the car sills. The side bearings of the car were blocked with short jacks and were raised when approaching curves. An engine attached to the cars hauled the tank on the cars to its new site, where a concrete base about level with the floor of the cars had been built for it close to the track.

Electric Locomotives are being introduced on the Vienna city lines to replace the existing steam locomotives. They have an unusual arrangement of four motor equipments on a two-axle truck, with two geared to each axle, and use 3,000-volt direct current on the three-wire system. The two motors on each axle are connected permanently in series which reduces commutation troubles by one-half, and the three-wire system allows a large number of operating combinations with the series-parallel system of control.

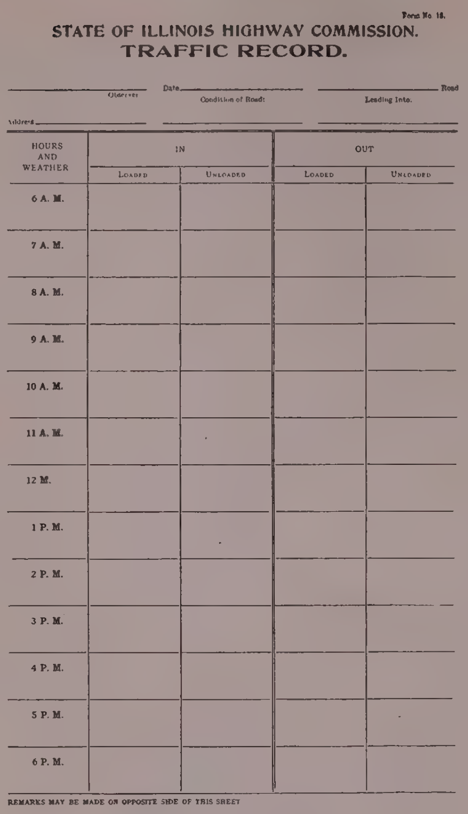
The Illinois Road Traffic Census.

An abstract of a paper read before the Illinois Society of Engineers and Surveyors, by Mr. A. N. Johnson, State Engineer, Illinois State Highway Commission.

So far as is known there has been in this country no systematic effort made to ascertain the actual number of vehicles which traverse what is ordinarily known as a well-traveled country road. Roads are usually described as well traveled or sparsely traveled as compared with one another in a particular locality, but the exact amount of use to which the roads are put has never been ascertained. It was, therefore, determined to make an actual count of the vehicles on a number of roads in different parts of the State (Illinois), the object being to ascertain if possible what is the difference in the traffic over roads leading into large towns and those leading into smaller towns; the effect which the condition of the roads has upon travel; the effect due to the industries in a particular neighborhood; and from the results to deduce further conclusions which might at first be considered as having no special bearing. On the other hand, no attempt has been made, nor was it intended, to sum the total traffic on all the roads, as this would be a practical impossibility, and for the present purposes not at all necessary. On a number of roads two stations, one near the destination of a road—that is near the city or town to which the traffic comes—and another station three or four miles out, have been established. In between these stations are usually found two or three cross roads which must supply the difference in the amount of traffic noted at the two stations.

This work was begun gradually with a few observers in the vicinity of Springfield, and one or two in other sections of the State. These stations were established in February, 1906, and from time to time, as other duties made necessary visits to other sections of the State, additional traffic stations were established until at present there is a total of 37 stations on which a traffic record is kept.

The method of counting and classifying traffic is, first, of vehicles going in or toward the city in which the station is established, and second, of vehicles going out or away from the town; distinction is also made between loaded and unloaded vehicles. The number of horses or animals attached to each vehicle is recorded and the record for each hour kept separate. A reduced sketch of the actual blank that is used is shown in an accompanying illustration. On the back of each blank instructions for taking the traffic record are printed as follows:



Form No. 18.

STATE OF ILLINOIS HIGHWAY COMMISSION.
TRAFFIC RECORD.

Observer ____ Date ____ ____ Road
Address ____ Condition of Road: ____ Leading Into: ____

HOURS AND WEATHER	IN		OUT	
	LOADED	UNLOADED	LOADED	UNLOADED
6 A. M.				
7 A. M.				
8 A. M.				
9 A. M.				
10 A. M.				
11 A. M.				
12 M.				
1 P. M.				
2 P. M.				
3 P. M.				
4 P. M.				
5 P. M.				
6 P. M.				

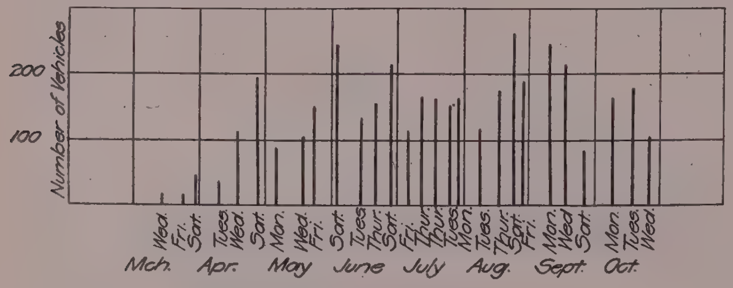
REMARKS MAY BE MADE ON OPPOSITE SIDE OF THIS SHEET

Traffic Record Blank.

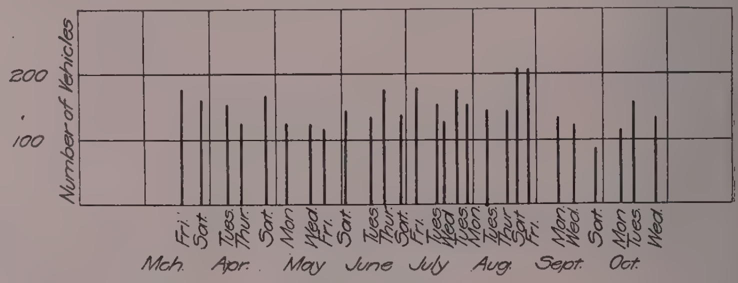
Instructions for Taking Traffic Census.—Read these instructions carefully; if any point is not clearly understood write for further information to the State Highway Commission, Springfield, Ill. 1. The observer should sign his or her name at the top of the record sheet in the proper space as indicated. 2. Fill in the date on which the record is taken. 3. In the space under "Condition of Road," state whether the road is dry and smooth, dry and rutted, frozen and smooth, frozen and rough, wet, with six inches of mud (or whatever may be about the depth of the mud). Do not state the condition of the road until the day is ended and then state as above directed the general condition for the entire day, using the words which best describe the actual conditions. 4. In the column headed "Hours and Weather," state each hour the condition of the weather as, "cloudy," "rainy," "fair," etc. 5. All vehicles going "IN" are those going towards town. All vehicles going "OUT" are those going away from town. 6. All passenger vehicles, as carriages and buggies, are to be classed as "unloaded." 7. All wagons carrying any load will be classed as "loaded," otherwise as "unloaded." 8. The method of recording the traffic is as follows: If a two-horse vehicle passes, put down a small figure 2 opposite the proper hour and in the correct column. If going in (or toward town), the figure should be placed on the left side of the sheet in the column headed "Loaded" or "Unloaded," as the case may be. A carriage of any kind should always be recorded as "unloaded," whether all the seats are occupied or not. Make an "A" for each automobile. 9. Aim to keep your record as clear and neat as possible. Use a medium hard pencil. Keep the pencil point sharp and do not moisten it. 10. Make your figures small and close together. 11. Each time that a record of traffic is to be taken you will be notified two days in advance of the date on which the record is to be taken. 12. As soon as the record for the day is completed, place it in the stamped and addressed envelope and mail it not later than the following day.

Each traffic station was established at some house on the road near enough to the city or town in question to include all the traffic going and coming to the country, but far enough out to exclude merely street traffic. The blanks were purposely made as simple as possible, with the idea that they could be kept by any bright boy or girl. The count was made at all stations on the same day, and were made about four times a month. The days were so selected that if the first count came on Monday, the next count would come some other day of the week; taking for instance, first Monday of one week, Tuesday of the next, Wednesday of the next and so on. In this way it would be possible to show what variation, if any, the day of the week made. As will be noticed, the blank provides for a record of the condition of the road and weather. In winter the traffic was recorded during the daylight hours; at other seasons of the year from 6 A. M. to 7 P. M. The observers were paid $1 for each day the count was kept. This general method of taking traffic census has proved in every instance satisfactory and secures accurate results.

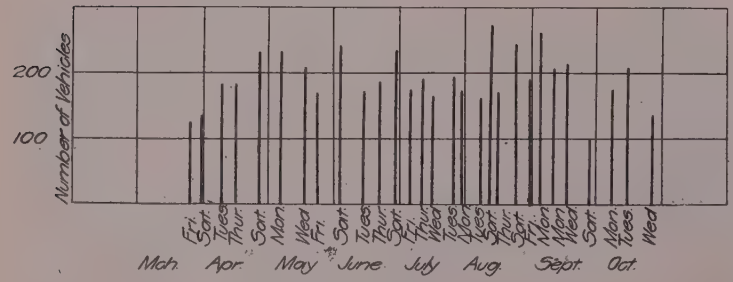
At least a year's observation would be necessary for any satisfactory conclusions, so that the results already obtained cannot be considered complete. Only a few of the stations show winter traffic, as the majority were not established until the spring or early summer. It is



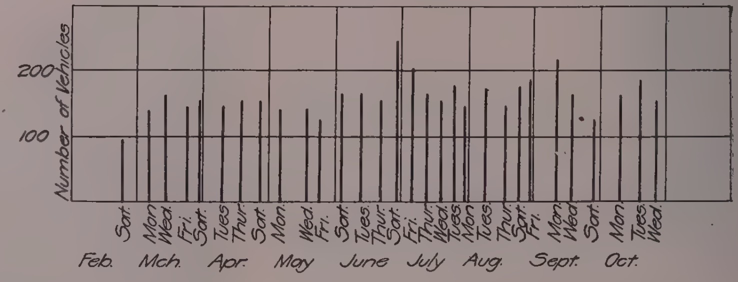
Road Entering Centralia.



Road Entering Peoria.



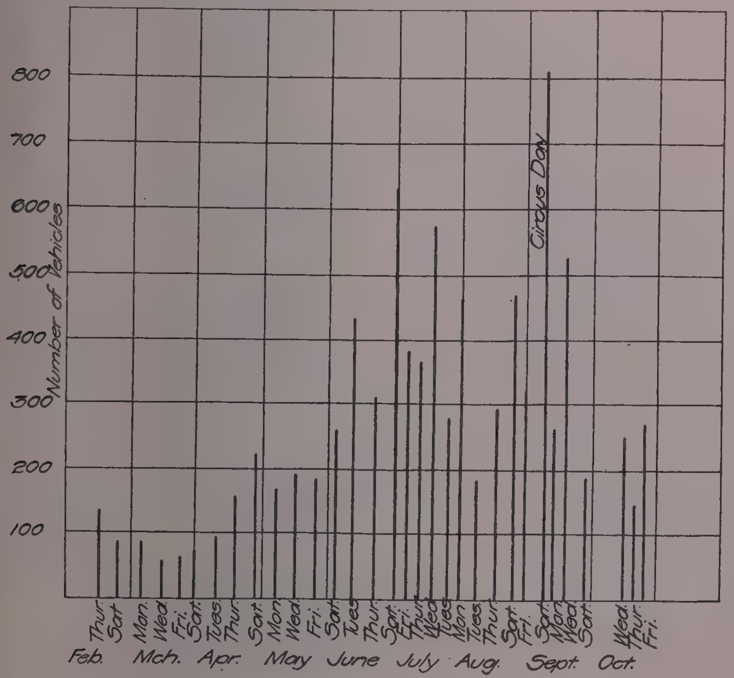
Udina Road, Elgin.



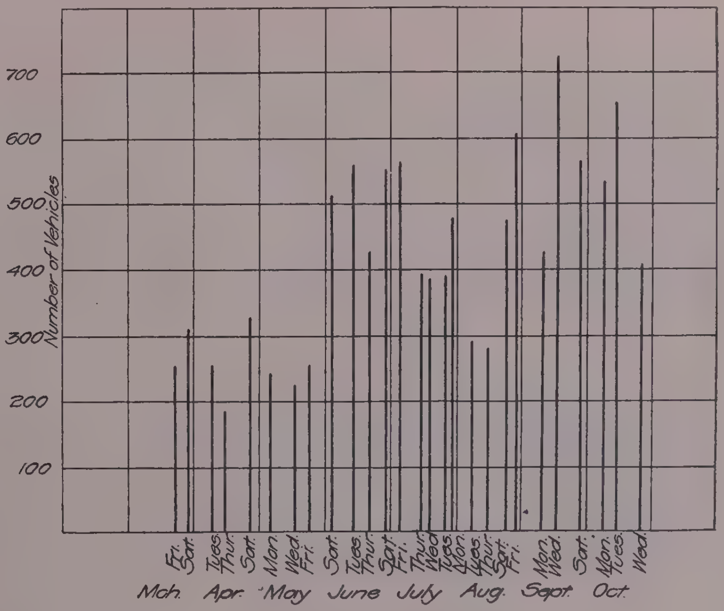
Lily Lake Road, Elburn.

proposed, however, to continue the observation at each station for at least a full year, as the importance of the data already collected fully warrants a continuation of this work. Five stations were established in the vicinity of Springfield, two on the main road south and two on the main road east (along each of these roads are interurban electric lines), and the fifth station established some time afterwards on a road northwest of the city. Double stations were also established on a road leading into Peoria and on a road near Rockford.

The most striking feature found in these reports is best brought out graphically as shown in the accompanying diagrams, which indicate very clearly the variation in the traffic on the roads into Springfield, Rockford, Centralia, Peoria, Elgin and Elburn. The height of the heavy lines represents the relative amount of traffic in each instance. It will be noticed that during March and the first part of April when the roads are extremely bad, the traffic into Springfield and Centralia, which is over earth roads, is very light, whereas the traffic into these same places during good weather is many times greater. The traffic into Rockford shows an increase in good weather, but the amount in bad weather is in very much greater proportion than on the earth roads. This traffic comes in over a macadam road. The traffic into Peoria, Elgin and Elburn, it will be noted, is remarkably uniform throughout the year. The roads in the vicinity of all these stations are gravel. In the vicinity of Elgin and Elburn dairy farming is carried on extensively, which necessitates daily marketing of products. The greatest influence on the traffic is the weather and the resulting condition of the roads.



Trask Bridge Road, Rockford.



Clear Lake Road, Springfield.

Another striking fact is that the size of the town to which the traffic comes is by no means a measure of the amount of traffic over the road. On these roads where there are two stations it has been found that at the farther station, which is but two or three miles beyond the station nearest town, there is very much less traffic, that is, the amount of traffic recorded on these roads extends for a comparatively short distance, so that the travel on the road two or three miles out is but one-fourth the amount on the portion of the road nearer town. It is, therefore, evident that if the amount of money to be spent on a particular road is to be in proportion to its use, the first two or three miles nearer town should have four or five times as much spent on them.

Traffic records were taken on special occasions, such as when a circus was in town, or whenever a similar important event took place. On such days the observers were instructed to take a count of the traffic whether or not it was the regular day for taking the census. The figures thus obtained, it is believed, show the maximum use that is made of a particular road, and it is therefore intended to show what may be considered as the maximum amount of traffic. Thus we find on July 12, on the road into Greenville, a total of 1,233 vehicles, while the average traffic at this time of the year is but 340. Likewise on September 6, on a road into Canton, 1,197 vehicles were counted, while the average at this time of the year is about 380 vehicles.

There is also to be found from a study of the individual reports a great variation in the hour of the day when the maximum traffic occurs. Thus the traffic into Elgin is fairly well distributed throughout the middle part of the day, while the traffic to Peoria occurs between 7 and 9 A. M. coming in, and 2 to 4 P. M. going out. The most marked hourly variation in traffic occurs on the road to Elburn. At this point each report shows a large amount of traffic between 8 and 9 A. M. going to town and between 9 and 11 A. M. leaving. These are instances where it is necessary for the business of a community to use the road not only every day in the year, but at a certain hour of the day.

As before stated, the data here presented is not considered complete and, therefore, conclusive deductions should not be drawn without additional records. It seems, however, that the evidence furnished warrants making some general observations. A country road is well traveled that has a daily average in fair weather of 300 vehicles or over; 600 vehicles a day is an exceptionally large traffic, and over 1,000 vehicles of very rare occurrence. The majority of the vehicles are reported drawn by two horses, seldom by more than two.

The greatest variation in the use of the roads seems to be about stations where there are nothing but earth roads, which necessarily become extremely bad in winter and spring. It is a practical impossibility in the vicinity of Springfield, for instance, or other places with similar road conditions, to engage in business pursuits which require the daily use of the roads such as is made of them about Elburn, Elgin and Rockford. The condition of the roads about the latter places is such that business can be done daily with certainty. It may be said, and possibly it is true, that the business about Springfield and other points does not require the daily use of the roads, but it is also true that these communities could not engage in any pursuits that would require such a use of the roads in their present condition.

The Elastic Modulus of Steel.

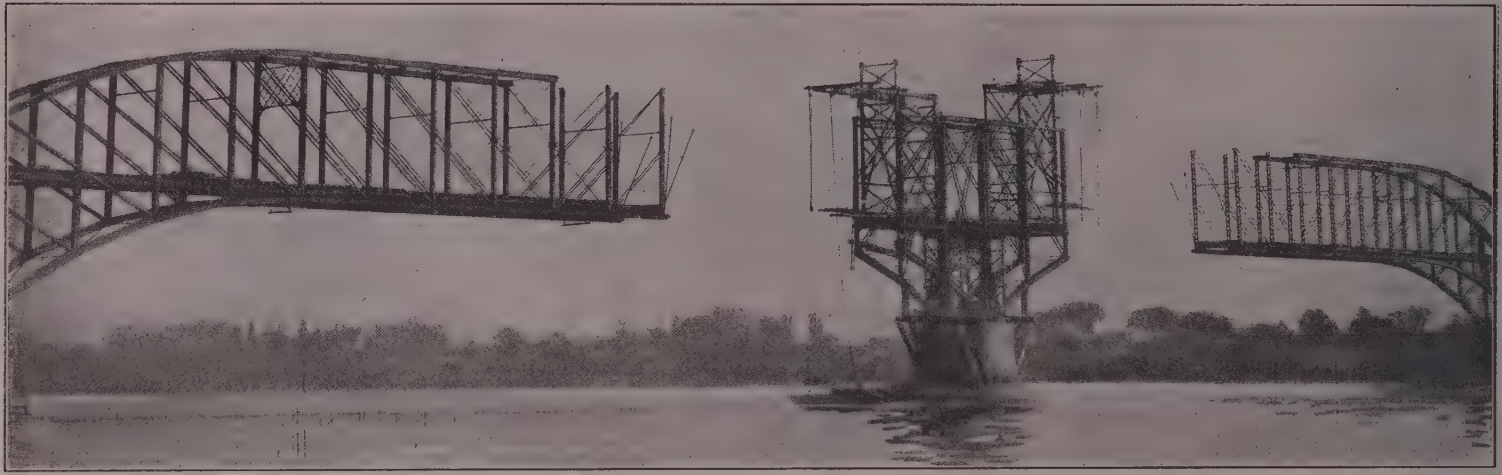
The elastic modulus of steel for small loads at the elastic limit has been investigated at the University of Maine by Mr. Henry W. Bearce, who has contributed an account of his experiments to the "Physical Review." About eight years ago, Mr. C. P. Weston published in the same journal an account of experiments which showed that even with loads as small as 0.5 gram, Hooke's ratio between stress and strain holds true. In Mr. Bearce's experiments the work of Mr. Weston was repeated except that the test bars were weighted to stress them to the elastic limit before the small test loads were applied. The bar was supported at each end on a knife edge, and at the center there was suspended a weight gradually increased in amount until a permanent set could be detected in the piece. A telescope with a micrometer head was used for this purpose, and enabled a very slight deviation from the original position of the rod to be detected. The load which caused the first noticeable permanent set was taken as the elastic limit, and employed as the initial load to which the 0.5-gram loads were added. The deflections in the rods were measured by the method of interference of light waves. Mr. Bearce draws two conclusions from the tests; first, there seems to be a slight increase in the elastic modulus as the bars reach their elastic limit, and, second, within the limits of errors of observation, Hooke's law holds at the elastic limit as well as under normal conditions.

The Great Strength sometimes exhibited by brick masonry well laid in good cement mortar, is shown by a brick cistern 7 ft. in diameter by 10 ft. deep, which was undermined by a flood at Terre Haute, Ind., and floated away for some distance, without breakage of any part of the masonry or water gaining access to the interior.

The Erection of Noteworthy Bridges.

Not long after the completion of the St. John's Bridge, as described in this journal a fortnight ago, the two 408-ft. channel spans of the Canadian Pacific Railway Bridge across the St. Lawrence River at Lachine, near Montreal, were erected by the cantilever method. The trusses were of the camel-back, pin-connected variety of the Pratt type, and were 40 ft. deep in the middle and 75 ft. at the center pier. They were designed as free trusses in service, but they were erected by the cantilever method at a height of 60 ft. above the swift, deep water. The approach spans having been first erected served as anchor arms, from which half of each channel span was erected in the ordinary manner, the remaining halves of the channel spans meeting on the center pier were erected simultaneously from the latter point, so that each balanced the other, and the incompleted structure was in equilibrium on a very narrow base during erection.

The two duplicate travelers used were light wooden towers with pairs of vertical posts extending above their tops at the forward ends and receiving guys which supported the extremities of the overhangs, one and one-half panels or 35 ft. long. The adjacent ends of the channel spans unite in a single vertical bent on the center pier, the width of which was not sufficient to provide supports for the first two panels of the trusses during construction. It was therefore necessary to build a temporary falsework for them, which consisted of transverse timbers projecting like corbels, beyond both faces of the piers, and supported at their extremities by knee-braces seated on a projecting course of the pier masonry. This provided bracket platforms 48 ft. wide and 28 ft. long on each side of the pier. Blocking was built on these to support the inclined lower chord end-sections and the first two panels of the trusses were erected with derricks and together formed a tower about 50 ft. square, on the top chords of which the travelers were assembled in a position from which they were able to move forward and complete the erection of the semi-trusses. The steel work was delivered by barges directly under the travelers in their successive positions and was hoisted by engines seated on the center pier. At the time this bridge was erected, no precedent existed for the simultaneous erection of balanced cantilever arms from such a narrow base, and that it was quickly, safely and economically accomplished at the head of the fierce Lachine rapids was considered a very creditable piece of engineering.



Double-Balanced Cantilever Erection of Lachine Bridge.

The Snake River Bridge of the Union Pacific Railroad, about 14 miles from Omaha, is an example of extremely rapid erection. The falsework and traveler were built, and three 217-ft. spans were erected, floor systems placed and the ties and guard rails put in in a total of 12 working days, with an average force of 70 men. The iron for the last span was brought from the storage yard, assembled and all pins driven in five hours and twenty minutes. Of the eight spans erected within twenty miles of this location, the time of erecting ranged from four hours and forty-five minutes for a 207-ft. span that weighed about 160 tons and was brought about 600-ft. from the storage yard, to 7 hours for a 270-ft. span.

Another instance of very rapid erection was that of the two 518½-ft. channel spans of the Cairo Bridge across the Mississippi. Each span weighed about 2,055,000 lbs. and had trusses 25 ft. apart on centers and 61 ft. deep with 30½ ft. panels. The first span was erected complete and the falsework and piles moved to the second span in six days. All the piles were driven, the falsework built and the steel erected for both spans in one month and three days, including five days of time lost waiting for iron. On one span erection was commenced at 2.30 p. m. Oct. 30, 1888, and the connections of the trusses and top bracing were finished at 2.50 p. m. Nov. 3, no work being done at night. The falsework was 104-ft. high and the water 20 ft. deep. Twenty-four men were employed delivering material from the yards and 50 men were employed assembling, erecting, etc.

Another example of very rapid work was afforded by the re-erection of a bridge across the Ohio River at Cincinnati. The freshet of August 26, 1888, carried off the falsework, the traveler and 650,000 lbs. of the superstructure of the 550 ft. of the channel span; within five weeks the lost steel had been replaced by new steel fabricated for the purpose; 1,200 50-ft. piles had been driven, 550 ft. of falsework 85 ft. high had been built, a new traveler assembled on it, and the bridge erected and opened for highway and double-track railway traffic.

Many of the bridges across the Ohio have suffered greatly from sudden floods which destroyed the falsework and in some cases the superstructure, so that the river had the reputation among early bridge erectors as being the most treacherous in the country. The Cincinnati Southern Bridge, which long had the record of being the longest truss span in the world, was built on old-fashioned upper-story falsework which was twice washed out during its construction.

The falsework for the Wheeling bridge had been built and a large part of the floor system and lower chords assembled on it, when a freshet overtook the erectors and washed out both falsework and steel work. Fortunately a large part of the timber and all of the steel was recovered excepting a single chord pin.

The falsework for the 260-ft. span of the Kentucky and Indiana Bridge was washed out and went down the river in an upright position for two miles before it collapsed; the timber was recovered ten miles farther down the river and was brought back and used again in the reconstruction of the falsework.

Reclaiming River Bed Coal Deposits at Harrisburg, Pa.

Anthracite coal is obtained by an interesting method of pumping from river bed deposits in the Susquehanna River in the vicinity of Harrisburg, Pa. The deposits extend all the way from Wilkesbarre to points below Steelton, and consist of accumulations of small particles of coal that have washed down the river from coal banks and culm piles in the anthracite region in times of freshets and high water. The coal occurs in small sizes, ranging from the pea to the buckwheat grades, with occasional mixtures of chestnut coal, the fine grades of anthracite having, it is observed, the peculiar property of rolling along the river bed in a strong current. The largest deposits occur at Plymouth, just below Wilkesbarre, and at Northumberland, where the north and west branches of the Susquehanna River come together. At Clarks Ferry dam, 16 miles above Harrisburg, about 25,000 tons are pumped from the river annually; and at Steelton, a short distance below Harrisburg, there is also a large deposit, the river at this point being both deep and wide.

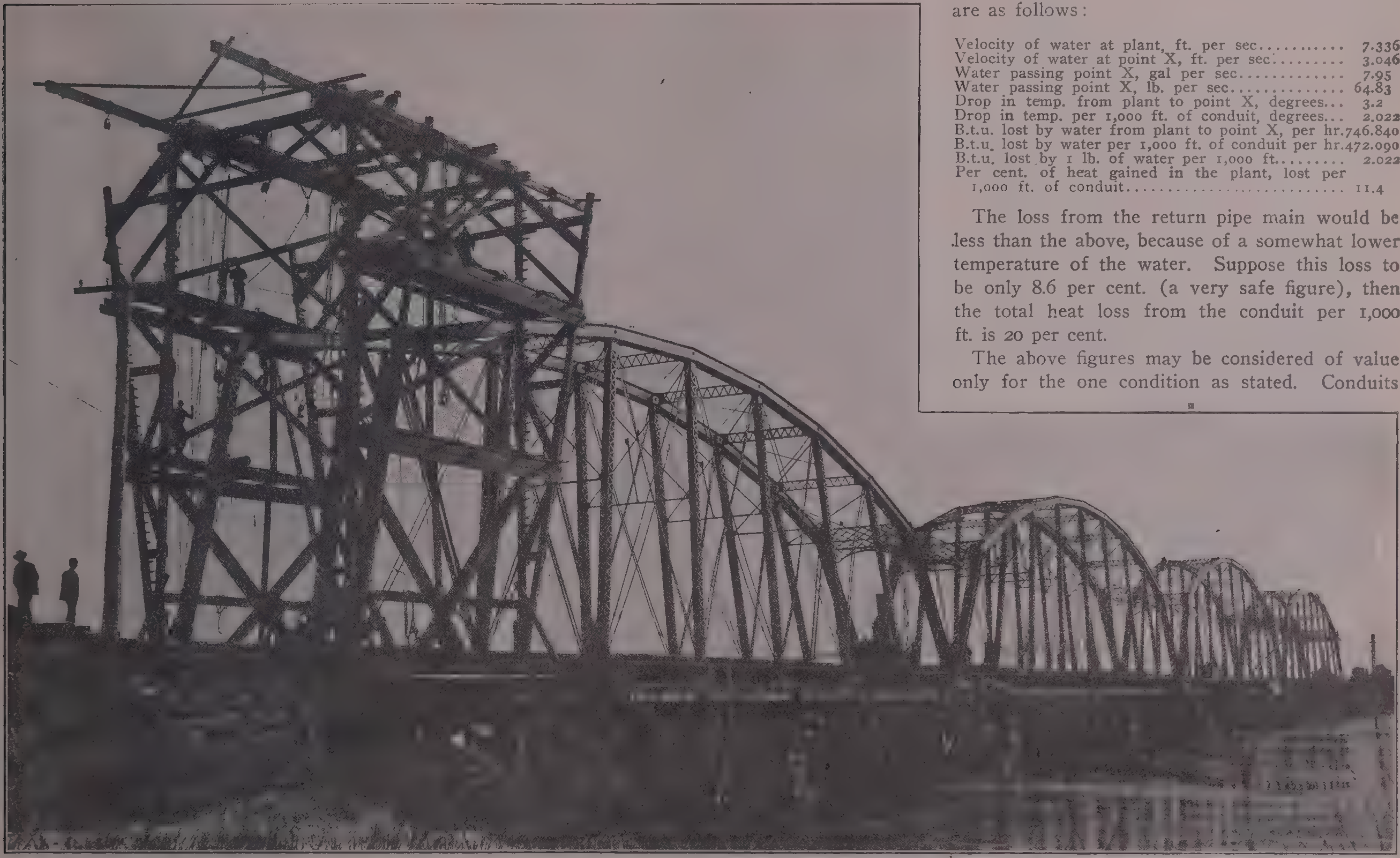
The coal forms with sand in bars at all eddies, still water beds, behind bridge piers, etc. At Harrisburg the supply is found chiefly in the lee of the many bridge piers in the river at that place. The size of the coal found here and at Steelton is principally No. 4 buckwheat with traces of pea coal. The coal is, for the most part, pure carbon, there being but very little slate, because the latter, being flat, will not roll along the river bed to any extent. The coal is remarkably clean after its long journey, and its heating value is as great, if not greater, than the same size of anthracite coal which has been transported by rail, as the heating value of coal stored under water does not suffer much loss. At Wilkesbarre and Nanticoke the river coal sells for $1.25 to $2.50 per ton according to its size, while the price of coal found at Harrisburg is about $1.50 per ton. The coal is taken from the river bottom by dredges and pumps at the various points, chiefly by the latter.

The Harrisburg Light, Heat & Power Company has a complete equipment for pumping the coal from the river at Harrisburg, which is similar to the others used on the river, so that a description of its operation and also some facts regarding the cost will be representative of the methods employed all along the river.

The outfit of the company comprises six scows, having a capacity of about 12 tons each, two deck scows and one stern-wheel shallow-draft steamboat for towing them to the shore when loaded. The steamboat is driven by a 20-hp horizontal engine, the stern wheel being driven by chain and sprocket. The coal pumping outfit is mounted on a deck scow and consists of a No. 6 sand pump driven by belt from a 12-hp portable engine. The coal pumping process consists of locating a coal and sand bed and anchoring the pumping outfit over it. The anchor is attached to a drag rope wound around a drum, the latter being connected by slow motion gear to the engine, so that when the dredge is anchored with the full length of the drag rope played out the drum is wound automatically so as to pull the dredge from one end of the deposit to the other.

The pump is primed in the usual manner before operations are begun. The suction pipe is a 6-in. wire bound hose about 8 ft. long fitted with a flared suction end and hangs over one side of the boat. Sand, water and coal are pumped together and are discharged on an inclined screen, mounted between the dredge and the flat deck scow and supported from a pole as shown. The screen has a ⅜-in. square mesh through which all of the water and sand pass out into the river. The sticks and stones are picked out of the coal while it is still on the screen and when the coal is thoroughly clean it is hoed into the scow. There are three men allotted to the outfit besides one man to run the steamboat, and one on shore to take care of the loaded flats as they are towed in.

The coal pumping process begins about March 1, or as soon as the river is free from ice, and ends about the 15th of December. During the season just closed the Harrisburg Light, Heat & Power Company pumped over 9,500 tons of coal, while only 13,500 tons were obtained by rail. The average cost of pumping the coal from the river and delivering it to the boiler room of the power house was 87 cents per ton; while during some months when the supply was plentiful the total cost per ton was a trifle less than 66 cents. The coal can be burned direct in furnaces properly fitted and with sufficient draft; but the lighting company mixes it with bituminous in the proportion of one part of bituminous to 10 parts of anthracite, due to lack of boiler capacity. Bituminous coal in Harrisburg costs $2.65 per ton.



Snake River Bridge and Traveler Used in Its Erection.

Heat Loss in Underground Hot Water Piping.

An efficiency test of the power plant and central heating system of the Merchants' Electric Lighting Association, of Lafayette, Ind., was recently carried out by Messrs. E. Faris, L. J. J. Owens and C. J. Peck, for a thesis investigation. The tests included the electrical equipment, the boiler plant and the underground distributing conduit and heating apparatus. As the tests were carried out under the supervision of Prof. James D. Hoffman, of Purdue University, who is chairman of the Committee of Tests of the American Society of Heating and Ventilating Engineers, the following abstract of the thesis covering the heat losses from the conduit mains was incorporated in the report of the Committee at the recent annual meeting of the Society.

The heating system under consideration is a two-pipe hot water system, with flow and return mains in the same conduit. The conduit is built up three-ply of 1-in. boards insulated from each other by tarred paper, the interior of the conduit being filled in with wood chips and then covered with crude oil. The conduits were laid in 1902 and when the test was conducted they were considered to be in a fair state of preservation.

The capacity of the system was about as follows:

Total square feet of radiation	118,000
Length of conduit in feet—10-in. main	450
8-in. main	1,200
6-in. main	4,700
5-in. main	1,700
4-in. main	6,800
Total length of all conduits, in feet	14,850
Total length of flow and return mains, ft	29,700

During the test on the conduit the following average conditions prevailed:

Duration of first test on conduit, in hours	10.
Pressure in flow main, lb. per sq. in	60.6
Pressure in return main, lb. per sq. in	32.23
Barometer, inches of mercury	29.5
Temperature in flow main at plant. degrees F	158.36
Temperature in return main at plant, degrees F	140.66
Outside temperature in degrees	31.2

To determine the heat losses from the conduit a Pitot tube was placed in the main 10-in. flow pipe at the plant and a second Pitot tube was similarly placed at a point X in an 8-in. section of the flow pipe at a distance of 1,582 ft. from the first tube. The velocity of the water passing each point was then calculated from the observed data. These readings are shown in the table below.

The results obtained from the above readings are as follows:

Velocity of water at plant, ft. per sec	7.336
Velocity of water at point X, ft. per sec	3.046
Water passing point X, gal per sec	7.95
Water passing point X, lb. per sec	64.83
Drop in temp. from plant to point X, degrees	3.2
Drop in temp. per 1,000 ft. of conduit, degrees	2.022
B.t.u. lost by water from plant to point X, per hr.	746.840
B.t.u. lost by water per 1,000 ft. of conduit per hr.	472.090
B.t.u. lost by 1 lb. of water per 1,000 ft.	2.022
Per cent. of heat gained in the plant, lost per 1,000 ft. of conduit	11.4

The loss from the return pipe main would be less than the above, because of a somewhat lower temperature of the water. Suppose this loss to be only 8.6 per cent. (a very safe figure), then the total heat loss from the conduit per 1,000 ft. is 20 per cent.

The above figures may be considered of value only for the one condition as stated. Conduits containing pipes of other sizes would probably have heat losses varying greatly in amount from that shown on the one carrying the 8-in. pipe. The results, however, do not show that, in the average conduit, with pipes insulated as these are, there is a considerable loss of heat during transmission.

RECORD OF PITOT TUBE OBSERVATIONS.

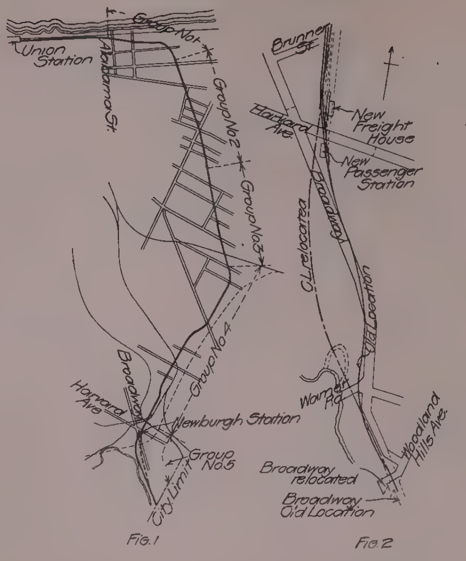
	Tube at Plant		Tube at X.	
Time.	Height In.*	Temp.†	Height In.*	Temp.†
10.15	1 7/16	153	1/4	149
10.30	1 1/2	152	3/16	149
11.30	1 7/16	154	1/4	150
12.30	1 7/16	158	5/16	154
1.30	1 1/2	157	9/32	154
2.30	1 1/2	161	3/16	159
3.30	1 1/2	161	1/4	158
8.30	1 1/2	168	5/16	159
Average	1.4765	157.2	0.2539	154

* Inches of mercury. † Temperature corrected.

An Atlas of maps showing the territory it supplies with electricity has been issued by the Ontario Power Co., Niagara Falls, Ont.

Stopping Pit Holes in Riveted Steel Conduits

A method of stopping leaks through pit holes in riveted steel water pipe has been used successfully at Rochester, N. Y., on a 38-in. steel conduit about 26 miles long, made of ¼ to ⅜-in. plate. After excavating to the pipe a dry pine plug is driven to temporarily stop the flow of the water, the plug being cut off flush with the outside of the pipe. The coating is scraped off clean and the metal dried, after which a coat of mineral rubber is applied. A sheet-lead gasket is then beaten down into contact with the concave side of a steel patch curved to fit the pipe, and the patch and gasket are applied to the pipe and tightly drawn up by means of a two-part band of ½x2-in. iron, bolted together. The edges of the lead are then calked and the whole given another coat of mineral rubber. In some cases where the leak has been near the lap of longitudinal and round seams, or where rivet heads hinder the ordinary procedure, the steel patch is first applied, spaced a short distance from the pipe and the intervening space filled with melted lead, after which the edges are calked as before. When, however, the patch has to cover a series of holes or pitted places which are so continuous as to preclude the use of individual small patches, or where the plate is so weakened as to need a continuous cover plate of considerable size, it is impossible to pour hot lead into the broad thin space under the plate as it is rapidly chilled by the water in the pipe. In such circumstances an elastic cement sold under the trade name of "Pyrocenit" has been successfully used, according to the recently published annual report of the city engineer, Mr. Edwin A. Fisher.



Track Improvements in Cleveland.

Track Elevation in Cleveland on the Pennsylvania Lines.

Plans prepared in accordance with an ordinance of the city of Cleveland passed in 1902 provide for the elimination of twenty-nine grade crossings on the Cleveland & Pittsburg R. R. from the southerly city limits in Newburgh to Alabama St., a distance of 6.8 miles. The work has been divided into five groups, which are shown in Fig. 1.

The work under contract at the present time is included in Group 5, extending from the city limits in Newburgh to Jones Ave., a distance of 1.1 miles, and consists of a re-location of the line to the west for four tracks, as shown in Figs. 1 and 2, the elimination of five grade crossings, and the construction of a new passenger and a new freight station. The work was commenced in August, 1905, and is substantially completed at the present time with the exception of the bridges and the adjustment of the buildings to the new grades of Broadway and Harvard Sts.

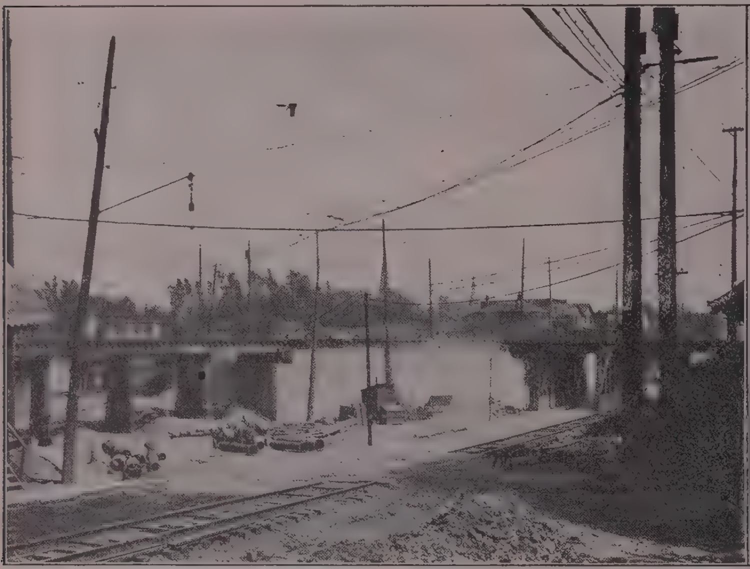


Fig. 3. Intersection of Broadway and Harvard Ave.,

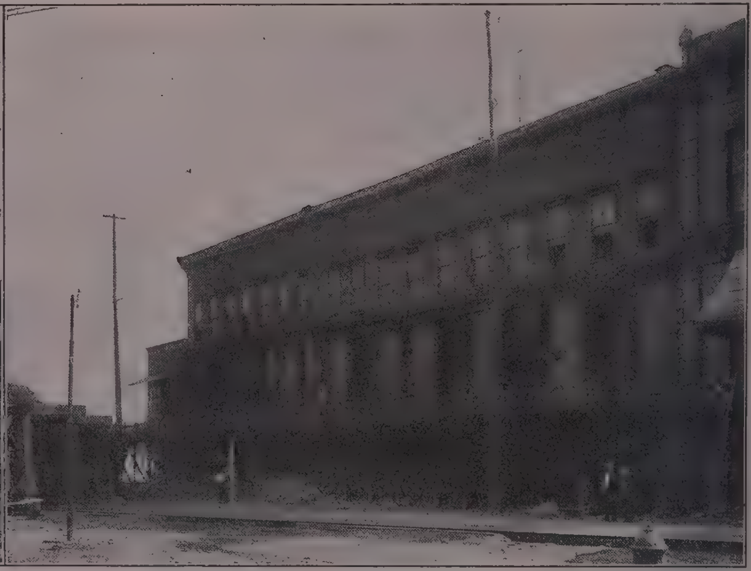


Fig. 4. Building Underpinned on Broadway.

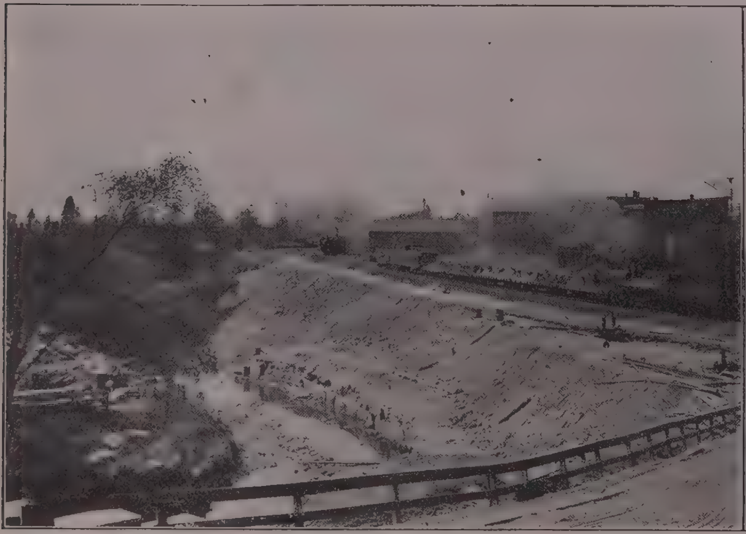


Fig. 5. View from Warner Road, May 22, 1906.

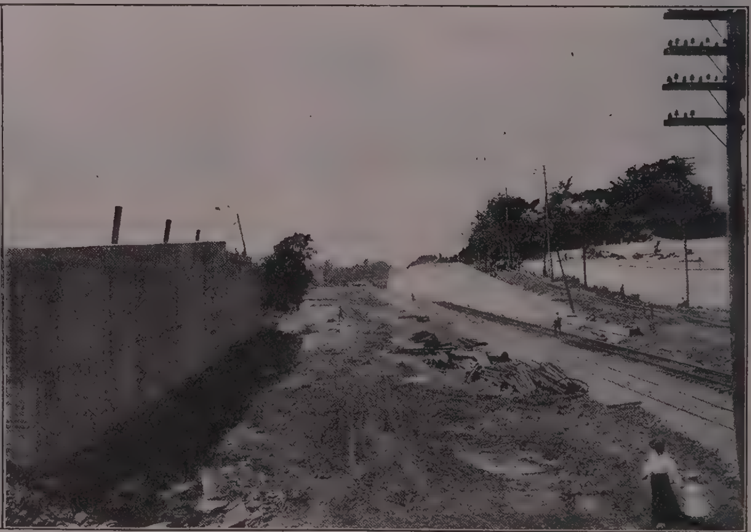


Fig. 6. View from Woodland Hills Ave.

Within the above limits, the railroad has been operated as a single-track railroad with a gauntlet 2,120 ft. in length, which contained a sharp reverse curve on a 1 per cent. grade. This piece of track was the only stretch of single track railroad between Pittsburg and Cleveland, and for a considerable distance was in Broadway.

Although it was necessary to introduce a 4-deg. curve on the new line, the grade was reduced from 1 to 0.3 per cent.

The location of the old line on Broadway made it necessary to delay the final excavation of Broadway to new grade until the railroad could be built on the new location. A temporary trestle was built across Harvard Ave. to support the old track, and excavation then made on Harvard and Broadway Sts., and trestles built across these streets on the new location, as shown in Fig. 3. The new line was then carried on these trestles and the street excavation completed, all excavated material being used for filling on the new line.

It was not possible to lower the buildings adjacent to the streets at the time the excavation was made, and it was necessary to shore all buildings on concrete piers or wooden posts. Temporary sidewalks were built at the old street grades as shown in Fig. 4.

The construction of the sub-grade on the new line involved the diverting of Mill Creek to the west and a fill of 120,000 cu. yd. in the old channel. The fill was made chiefly of material taken from a borrow pit about one mile south. The material was handled by a 45-ton Vulcan shovel, loading into cars of 3 and 4-yd. capacity. These were hauled in trains of 10 cars each and dumped from a trestle over the creek. The work was done entirely in the winter with two 10-hour shifts each day. The re-location of the channel and the new fill are shown in Fig. 5.

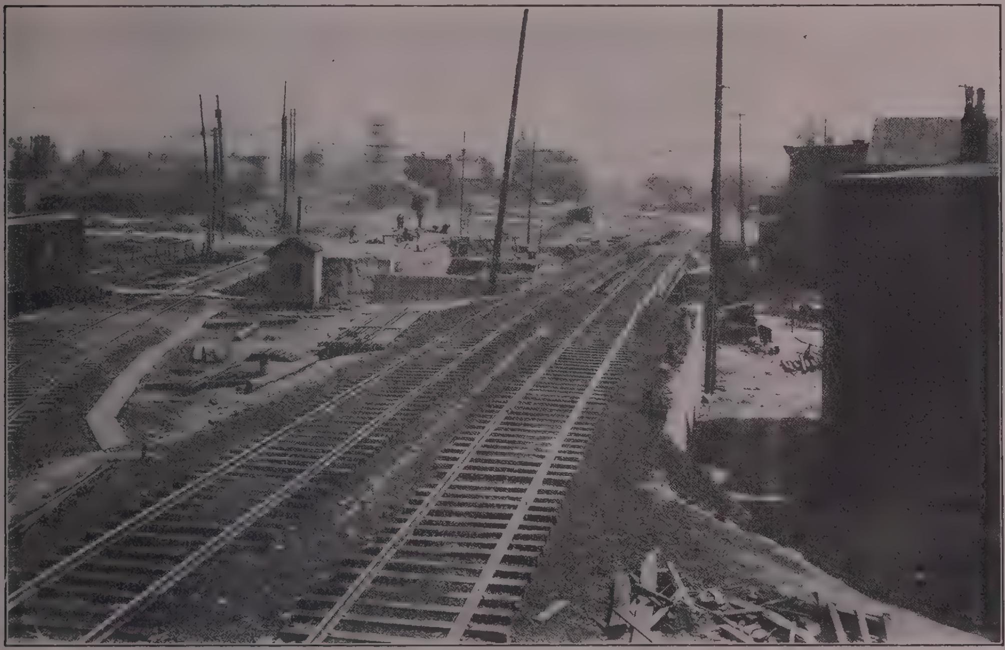


Fig. 7. New and Old Track Location near Broadway and Harvard Ave.

Concrete was used in the construction of the retaining walls and abutments, but bridge seats and coping are sandstone. Concrete which was placed during freezing weather was protected by a system of steam piping running from the steam mixers. The piping was protected by tarpaulins. Concrete was mixed by steam mixers, and was carried to the work on trestles in small cars.

The highway bridges at Warner Road and Woodland Hills Ave. are of pony truss design with reinforced concrete floor. All railroad bridges are of solid floor construction, waterproofed with concrete and Hydrex felt. The retaining walls forming the passenger station subway were waterproofed with Hydrex felt and backed with common brick.

Plans for the work were prepared in the office of Mr. R. Trimble, chief engineer of maintenance of way of the North West System, Pennsylvania Lines West of Pittsburg, under the general supervision of Mr. Thomas Rodd, chief engineer, and the construction work was in charge of Mr. B. E. Tilton, from the office of the chief engineer of maintenance of way.

Philippine Irrigation.

Irrigation problems in the Philippines are being investigated in many parts of the islands by the insular Bureau of Engineering, the studies dealing both with new projects and with the improvement and extension of works constructed by the Spaniards. Irrigation is extensively practiced throughout the islands, even by certain Igorrote tribes. The most extensive works are those constructed by the friars. One of the studies made by the Bureau was the investigation of the dams, ditches and tunnels of the irrigation works in Cavite Province. This system on the estates previously owned by the friars is the result of more than a century of intelligent development. It is estimated that 25,935 acres have been under irrigation. The number of dams examined was 43, about half of those connected with the works. The heights varied from 10 to 75 ft., the largest being 50 ft. high and 900 ft. long. They are constructed of masonry, laid in horizontal beds about 15 in. thick. Lime mortar is used exclusively. The profiles vary greatly, but all are generous. Notwithstanding the use of lime mortar, there is little leakage through the dams, and the leaks that have been found were probably due to cracks caused by earthquakes. The earthquakes, however, have not done any considerable damage in this district. The works, on the whole, are in good condition, though there are few dams in which the aprons do not need some repairs. Mr. H. F. Labelle, assistant engineer of the insular Bureau of Engineering, who reported on these works, estimates the cost of these repairs at $5,650. The ditches and tunnels in many of the systems were built with too flat a slope, and as a consequence from 6 to 12 in. of sediment has been deposited in them. The sections of the tunnels, which resemble each other closely, are 4 to 7 ft. wide, and 5 to 7 ft. high. They are cut through the rock, and have no lining. The tunnel arch is circular, or elliptical, and in one case a pointed arch is used. Several of the longer tunnels have shafts, some of them lined with masonry, which facilitate the cleaning of the tunnel. More than half of the canals and tunnels issuing from dams have no head-gates or regulating works, and in only one case are stem-operated gates in use.

The Method, Cost and Results of Tarring Heavily-Traveled Macadam Streets in Chicago.

During the season of 1906 the South Park Board of Commissioners of Chicago tarred the surface of more than 106,000 sq. yd. of the most heavily traveled boulevard streets in that city, in an endeavor to overcome the excessive cost and difficulty of properly maintaining those streets under the traffic to which they are subjected. This Board has charge of the construction and maintenance of the extensive park and boulevard system on the South Side of Chicago, embracing 2,228 acres of parks and 45 miles of park drives and boulevards. These drives and boulevards are almost entirely surfaced with limestone macadam which under normal conditions produces one of the most satisfactory roadways for light traffic that can be secured. Since the advent of the motor-car, however, and particularly during the past two or three years, these macadam drives and streets have been maintained in many places only at an unwarranted expense, while in some instances it has even been practically impossible to keep their surfaces in good serviceable condition during the spring months. The tarring was undertaken on a small scale early in May of last year in an experimental way, in an endeavor to find a method of insuring the surface of the macadam against the exceedingly detrimental effects of automobile traffic.

The first tarring work that was done embraced 3,160 sq. yd. of street surface on Michigan Ave. between Twenty-third and Twenty-fourth Sts. Michigan Ave. is a boulevard, 50 ft. between curbs and 5.73 miles long, which is the only exclusively light-traffic street leading from the extensive residence districts on the South Side of the city to the central business district. It is also a boulevard connection between the drives and boulevards of the park system on the South Side and those of the park system on the West Side of the city. Besides, it carries toward its northern end practically all of the light traffic between the South and North Sides. The amount of traffic on this boulevard has always been proportionately very heavy, but since automobiles have come to be used so extensively for business as well as for pleasure the traffic passing along it has increased greatly over the former volume. This increase in the volume of traffic is largely all automobiles, and at the same time many of the horse-drawn vehicles which formerly used this boulevard have been replaced by automobiles.

The result of the comparatively recent change in the nature of the traffic over Michigan Ave. has been to convert the surface of the latter from the smoothest and most uniformly good macadam drive in the city, and, in fact, from one of the best that could be built, to a surface that can scarcely be kept free from pits and loose stone. This condition is particularly aggravated in a length of the boulevard about three miles long, extending from Thirty-third St. north to the business district. At Thirty-third St. a connection is made with Grand Boulevard, which in turn connects with the drives of Washington and Jackson Parks and with the streets of the better class residence districts near Lake Michigan.

The first stretch of the surface of this boulevard to be tarred is 1½ miles north of the connection with Grand Boulevard at Thirty-third St. and embraced a section the length of a city block and the full width of the drive. Although this early work was somewhat experimental, inasmuch that practically no results of previous experience along these lines were available at that time, the methods of preparing the macadam and of spreading the tar on the latter followed on this block were adhered to generally in all the tarring that was done where the macadam had to be re-surfaced. The upper part of the old macadam in this block and in those adjacent to it was pretty badly loosened and rutted in places so that it would have been necessary to have re-surfaced it even though the tarring had not been done. In preparing for the tar, the surface of the macadam was first cleaned of all road detrius. The upper 3 in. of the macadam was then thoroughly loosened with picks in the wheels of a road roller, which was followed by a team with a harrow. The macadam along the edges of the drive which had not been reached in this manner was loosened by hand. As the stone was very dry below the surface it was thoroughly sprinkled after it had been loosened. The wet stone was then rolled well with a 10-ton steam roller and when it had compacted thoroughly was allowed to dry on the surface before the tar was applied.

A coal tar furnished by the Barrett Mfg. Co. and said to be free of water and of the lighter oils was used in all of the work. This tar was delivered in tank wagons which carried a furnace in which a wood fire could be maintained under the tank. The tar was never heated above 212° Fahr., however, and generally not close to that temperature, only enough heat being applied to reduce the tar to a sufficiently fluid condition so it would flow readily. The tar was drawn from the tanks into 5-gal. tin buckets fitted with a bail and spout, and was poured on the prepared macadam surface from these buckets, care being taken to distribute it well, although no brushes or brooms were used for spreading or leveling. After a coat of tar varying from ⅛ to ¼ in. in thickness was placed in this manner and before it had hardened, a layer of limestone screenings varying in size from dust to ¼-in. pieces was spread over it. This layer of screenings was about ¼ to ⅜ in. thick and was spread as evenly as possible by hand with shovels, the material being scattered with a swinging motion of the shovel and leveled with hand rakes. A 5-ton steam road roller was then run back and forth over this layer of screenings to compress the latter into the tar. Finally, a light coat of torpedo sand was spread over the screenings to fill up the few remaining small voids and to relieve the glare from the white, or at best light gray limestone. The traffic was kept off the block for 24 hr. after the tarring had been finished.

The results obtained with this experimental block were so satisfactory that the tarring was continued south on Michigan Ave., to Thirty-ninth St., with a total of 47,110 sq. yd. The central one of three drives on Grand Boulevard, which drive is 50 ft. wide and 2 miles long, together with approaches at each end of this boulevard, with a total of 68,651 sq. yd., and about 17,600 sq. yd. of drives on Drexel Boulevard were also tarred in practically the same manner that has already been described. In much of this work not on Michigan Ave., it was only necessary to thoroughly clean and level the surface of the macadam before applying the tar, as the traffic had in few places been heavy enough to have had such a bad effect on the macadam as on Michigan Ave. At some places not on the latter it was necessary, however, to do considerable work in leveling up the surface and in adding screenings before the tar was applied.

The cost of re-surfacing and tarring the block on Michigan Ave. is given in considerable detail in Table 1. The cost of the re-surfacing, tarring and supplies are given separately, and include every expense involved. The labor cost $127.42; tar, $73.32; and screenings and miscellaneous supplies and expenses, $70.63. The average total cost of 9.33 cents per square yard for the re-surfacing and tarring agrees closely with the total average cost of the remaining 34,530 sq. yd. on Michigan Ave. It should be borne in mind in this connection that the macadam on this street would necessarily have been re-surfaced even though the tarring had not been done.

Table 1.—*Cost of Tarring One Block of Macadam on Michigan Ave.*

Labor for Resurfacing—	Hours.		
1 Steam roller using pick on drive	4	$2.00	
1 Steam roller using rooter on drive	4	2.00	
2 Laborers attending to rooter	4	1.75	
1 Steam roller using picks	4	2.00	
1 Steam roller using rooter	4	2.00	
1 Steam roller rolling drive	8	4.00	
1 Steam roller rolling drive	4	2.00	
1 Steam roller rolling drive	1	.50	
2 Laborers attending to rooter	4	1.75	
2 Laborers spading up drive	4	1.75	
1 Team harrowing drive	4	2.20	
1 Team sprinkling water	4	2.20	
1 Team hauling supplies, kindling, etc.	8	4.40	
4 Laborers spading drive	8	7.00	
1 Laborer cleaning cross walks	2	.43	
2 Teams sprinkling water	12	6.60	
1 Team hauling harrow and pick to Washington Park	4	2.20	
1 Team hauling dirt to Grant Park dump from gutters	4	2.20	
1 Night watchman		1.61	
4 Laborers spraying drive	32	7.00	
2 Steam rollers rolling drive	12	6.00	
2 Teams sprinkling water	12	6.60	
1 Night watchman		1.61	
1 Steam roller rolling drive	5	2.50	
1 Laborer putting on screening	5	1.09	
1 Laborer cleaning cross walks	3	.65	
1 Team sprinkling water	8	4.40	
1 Night watchman		1.61	
2 Watchmen (1 day and 1 night)		3.22	
1 Foreman (3 days)		9.00	
1 Water boy (3 days)		3.00	
		$95.27	$95.27
Material—			
1 Gal. Kerosene oil		.11	
4,200 lb. coal		14.60	
1 load screenings (3 yds.) at $1.65		4.95	
		$19.66	$19.66
Cost of Tarring—			
9 yds. screenings, $1.65 per yd		14.85	
Labor		25.75	
1 team		4.40	
19 yds. torpedo sand		33.25	
1,128 gal. tar		73.32	
Six 16-in. gutter brooms		2.87	
Steam roller (½ day)		2.00	
		$156.44	$156.44
			$271.37

Sq. yd. resurfaced, 3,160; average cost, 9.33 per sq. yd.

Table 2.—Cost of Tarring Macadam Streets.

	Surface Tarred, Sq. Yd.	Tar Used, Gal.	Cost of Tar in Place, Per Sq. Yd.	Cost of Screenings in Place, Per Sq. Yd.	Cost of Rolling Tar and Screenings, Total.	Total Cost of Tarring, Per Sq. Yd.
Michigan Ave., 23d to 24th St.	3,160	1,128	$0.027	$0.023	$2.00	$0.051
Michigan Ave., 24th to 35th St.	34,530	16,199	0.033	0.027	34.63	0.062
Middle Drive, Grand Boulevard, 35th to 51st St.	62,652	29,209	0.033	0.027	67.27	0.062
Grand Boulevard, 51st St. to Approach	2,576	959	0.026	0.022	1.50	0.050
Grand Boulevard, 35th St. to Approach	3,423	829	0.018	0.025	6.47	0.045
Totals and averages	106,341	48,324	$0.032	$0.027	$111.87	$0.061

The actual cost for tarring alone on 106,341 sq. yd. of macadam street surface treated in five different instalments is given somewhat in detail in Table 2. The figures in this table are based on unit costs, prices for labor, hours in the working day and so forth, which were practically the same as those given in detail in Table 1. These figures were compiled from data kept as much in detail as those given in Table 1. The total average cost of the tarring alone, including the tar, screenings and sand and the placing of these materials varied from a minimum of 4.5 cents for a small percentage of this work to a maximum of 6.2 cents per square yard, with a grand total average of a trifle under 6.1 cents. This does not include the cost of cleaning, re-surfacing and re-dressing the macadam, which under normal conditions on drives other than on Michigan Ave. cost in the neighborhood of 3 cents per square yard on the average.

The results obtained by tarring the surface of the macadam are considered sufficiently satisfactory to justify the continuance of the work on a more extensive scale during the coming season. The tar penetrated the macadam to a slight depth only, and in some cases the coating of tar was not over ⅛ in. thick. It effectually protected the macadam, however, against the action of the motor-car wheels so long as it remained intact, and where it was applied no re-surfacing has been required since, although untreated portions of the drives adjacent to those portions which have been tarred will have to be re-surfaced in places during the coming spring. At the same time, the necessity and cost of sprinkling were greatly reduced where the tar was employed, the estimated saving of sprinkling on the tarred surfaces over the amount required on surfaces not tarred being about 60 per cent. Practically the only sprinkling required was that necessary to lay the dust blown on the tarred surfaces, or brought on by traffic. As sprinkling a 40-ft. macadam drive has been found by the South Park Board of Commissioners to cost on the average $97.37 per mile per month during the season of 8 to 9 months, the actual saving in sprinkling alone is considerable. On the other hand, the tarred surfaces have been in good condition for traffic in all kinds of weather, while the untreated surfaces become quite loose and raveled in soft weather under automobile traffic and are difficult to keep free of dust at other times. These additional benefits derived from the tarred macadam surfaces over those not tarred would seem alone to justify the tarring, but the expectation is to be able to fully warrant the continuance of the latter on a purely financial basis.

The first surfaces tarred have received the heavy traffic on Michigan Ave. during the past summer, fall and winter and are still in serviceable condition. Some of the work done later, although it did not receive as much traffic as that previously completed, has worn through in spots. This wearing through is believed to be due in all cases, practically, to poor material or to imperfect details of laying. As the tarring was all done in a somewhat experimental way no method of testing was established to determine before the tar was used that it was free of water and of the lighter oils. At the same time, the best manner in which to prepare the macadam surface to receive the tar had not been determined, although experience indicates that the methods of preparation described were satisfactory when carried out properly. In some cases wet weather prevented the application of the tar for several days after the surface had been prepared, and in one or two instances the tarring was probably commenced before the surfaces had become sufficiently dry. In fact, wet weather has been found to be the greatest obstacle to the successful application of the tar.

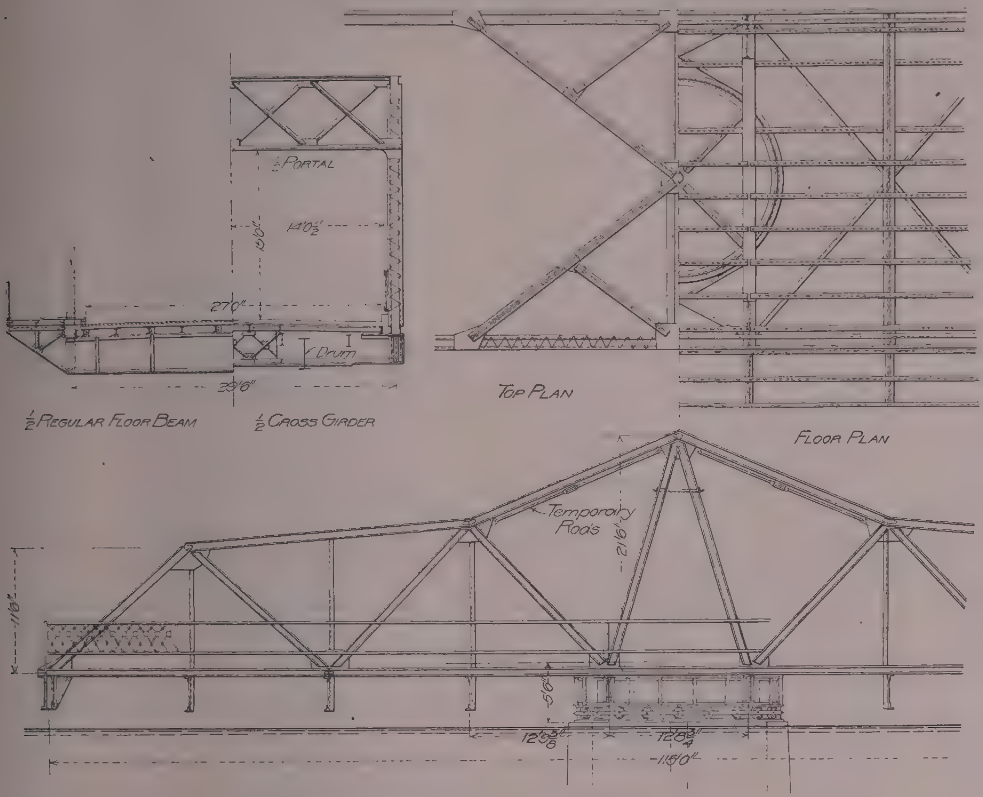
The worst season of the year on macadam drives in Chicago is generally the spring months. As none of the tarred surfaces have gone through this season, it is questionable just what will have to be done with them when the weather has settled. The worn spots will at least have to be repaired and there is a probability that the tar coating will have to be replaced almost entirely. In no place where the tarring was done will it be necessary, however, to re-surface the macadam to any great extent. The actual financial results of the tarring cannot be determined until the work has been followed through at least another season, although the general results have been satisfactory from every other standpoint.

The tarring was all done by day labor by the South Park Board of Commissioners, the information from which the foregoing notes were prepared being furnished by Mr. Linn White, engineer of that Board.

The Excavation in Culebra Cut, Panama, in twenty-three working days in February amounted to 638,644 cu. yd. Had there been a full month the total would have been 722,000 yd., according to Chief Engineer John F. Stevens.

The Bass River Draw-Bridge, Beverly, Mass.

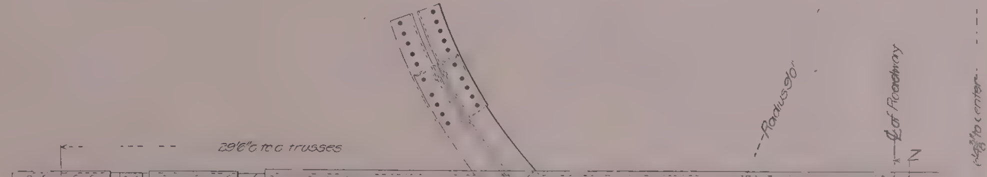
The Bass River highway drawbridge at Beverly, Mass., has a total span of 115 ft. between abutments, providing a 40-ft. clear opening at each side of the center pier. The bridge is about 35 ft. wide over all and has a concrete center pier 20 ft. in diameter with the top only 5½ ft. below the roadway, a condition which required some special features of construction to keep the turntable and operating machinery within restricted vertical limits.



Arrangement of Trusses, Girders and Drum.

The two trusses, 29½ ft. apart on centers and 21½ ft. deep in the center, having riveted connections and virtually form two four-panel spans of about 51 ft. each, reaching from the center pier to the abutments, but having their bottom chords continuous across the drum and their top chords connected by inclined members with the top of the center tower. For purposes of adjustment, the center panels of the top chord are provided with sleeve-nut rods which enabled the extremities of the span to be raised or lowered to suit the end bearings, but which were removed after the erection was completed. The height of the trusses is only 11½ ft., which precludes top lateral bracing except over the center pier, where diagonal braces are run from the hips of the side trusses to the top of the tower, giving a portal effect and providing sufficient transverse rigidity. The floorbeams are riveted to extensions of the vertical posts below the bottom chord and those at the ends have solid web-braces to the trusses. The floor system consists of I-beam stringers X-braced with single angles and covered with crossed layers of plank.

An interesting feature of construction is the simple method of supporting the trusses from the drum at a minimum elevation, the bottom chords being only a few inches clear of the top flanges of the drum. The drum is a cylindrical plate girder 34 in. deep and 18 ft. in diameter with two 4x6-in. angles in each flange. It is intersected by two transverse bearing girders 39 in. deep, 31 ft. long and 12 ft. 8¾ in. apart on the center. They have 9/16-in. web plates about 11½ ft. long at each end leaving between them an open center panel about 7½ ft. long, which is braced with three panels of diagonal angles. The top and bottom flanges are made of pairs of 6x6x⅝-in. angles and 14x⅝-in. cover plates; the bottom flange is about 4 in. above the bottom flange of the drum while the top flange is 12 in. above the top flange of the drum. The web of the girder is slotted to allow the drum to pass through it and is spliced across the latter by web plates and by bent cover plates on the vertical flanges of the lower chord angle.



Intersection of Drum and Bearing Girder.

The transverse girders are thus supported at two points about 13 ft. apart by the drum and cantilever about 8 ft. beyond them to carry the bottom chords of the trusses, which they receive on horizontal bearings provided by reinforced angles riveted to the web just below the top flange angles, which are cut to clear. The center pivot is a hollow casting 3 ft. in diameter, with horizontal shoulders supporting annular plates to which the four radial plate girder drum struts and the twelve radial rods for the rollers are attached. The span is swung by a pinion operated by hand and engaging the circular rack integral with the track plates, and is locked by a horizontal 4x⅞-in. bar 2½ ft. long riveted at one end and engaging trough-like cast-iron sockets bolted to the bridge and to the pier. Adjustment for the anchor bolts in the track segments and in the pivot casting was provided by setting vertical tin cones 4 in. in diameter at the top and 6 in. in diameter at the bottom in the pier concrete. The bolts with double nuts and washers at the lower end were dropped into the spaces cored out by these cones, and after the castings were in exact position, the spaces were grouted, thus securing the bolts without difficulty.

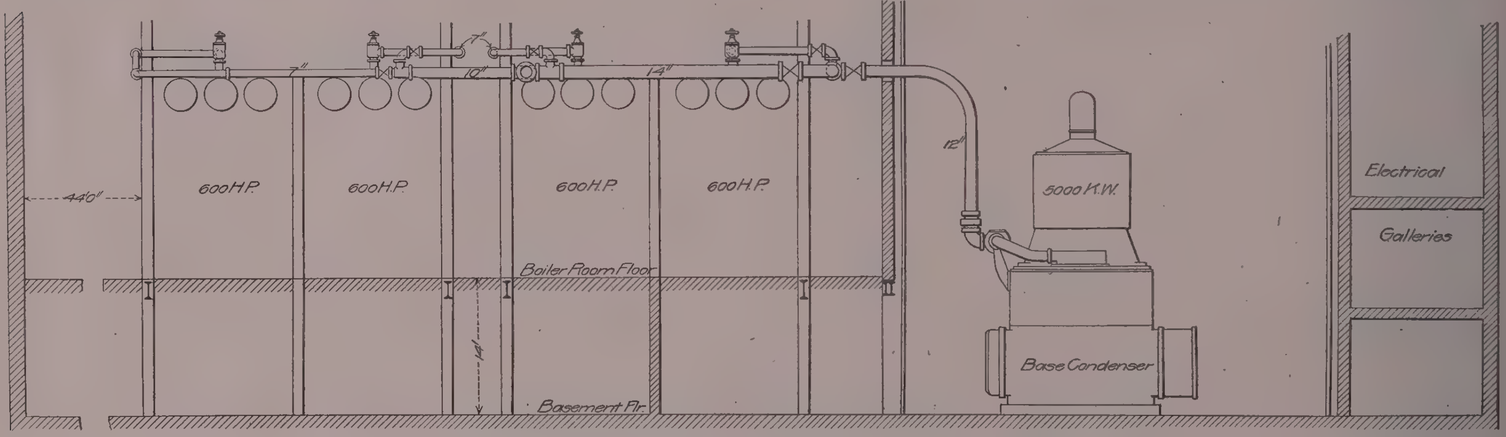
The bridge was designed and erected by the Boston Bridge Co., Mr. M. F. Brown, chief engineer.

The Number of Accidents on railroads in the State of New York as reported to the Board of Railroad Commissioners during the year ending June 30, 1906, was 959 persons killed, and 2,105 injured. Of the persons killed, 23 were passengers, 357 were employees, and 579 classed as "others," neither passengers or employees. Of the injured 342 were passengers, 1,424 employees, and 339 "others." It will be noted that the number of passengers and employees injured far exceeded the number killed, whereas the number of "others" injured was considerably less than the number killed. One passenger was killed in every 4,598,173 carried, and one injured in every 309,234 carried.

New Power Plant of the Potomac Electric Power Co. of Washington, D. C.

The Bennings power station of the Potomac Electric Power Co., of Washington, D. C., which has recently been completed, is a 19,000-kw. plant having a concrete building and steam-turbine units. The Potomac Company is a subsidiary corporation of the Washington Railway & Electric Co., which supplies the greater part of the power used for lighting, motors and street railway operation in the District of Columbia. The plant is intended to supplement a number of old power stations of the company, and has been located at Bennings, on the eastern branch of the Anacostia River, where an abundant supply of water for condensing purposes is available, and there is ample room for extension. A large tract has been secured, with an extensive water front, which, together with a spur from an adjoining railroad, renders shipping possible by water or rail.

The power house is a 164x240-ft. building with a steel frame and hollow concrete block walls. It is divided into a 180-ft. boiler room, and a 164x60-ft. turbine room, with a series of 15-ft. galleries for wiring and electrical control apparatus. The turbine room has unusually high head room to provide for a traveling crane over the machinery, while the boiler division has a 14-ft. basement and a head room of 30 ft., on the main floor under the coal bunkers. An unusual feature of the boiler room arrangement is that the basement is on a level with the turbine room floor, while a series of operating galleries surrounding the turbine units are on a level slightly higher than that of the boiler room floor. A portion of the boiler room basement opens directly into the turbine room, the division wall between the boiler and turbine rooms starting from the main boiler room floor level and being supported on steel work. This open portion of the basement is devoted to two exciter units, the boiler feed pumps, the oil pumps, two duplex house pumps, oil filtering tanks and testing tanks. The remainder of the basement, which is separated from this portion by a concrete block wall, contains coal and ash handling machinery, a repair shop, store room and a locker and toilet room.



Sectional Elevation Showing Arrangement of Steam Piping.

The steel frame in the boiler room carries elevated coal bunkers and in the turbine room supports a crane runway. The walls with few exceptions are built of hollow concrete blocks supplied by the Lake Stone Co., Washington, and are 1 x 1 x 3 ft. For the lintels and sills of doors and windows, special blocks were used reinforced with ¾-in. rods. Some of the lintels have a span of 12 ft. The pilasters and cornices are of concrete and were designed to harmonize with the tall chimneys and effect a pleasing exterior appearance. About 800 tons of structural steel were used in the construction of the building.

The station now contains two 2,000-kw., and two 5,000-kw. Curtis turbines, while space is provided for an additional 5,000-kw. unit. The plant lay-out is on the cross boiler room plan, there being two firing floors, with rows of opposed facing boilers arranged at right angles to the partition wall, providing space for a total of twenty-four 600-h.-p., water-tube boilers. There are three reinforced concrete stacks, located in a crosswise space in the center of the boiler room between boiler settings, each having breeching connections to a longitudinal row of eight boilers. There are two elevated coal bunkers, one over each firing floor, which have a combined capacity of 1,300 tons. By this arrangement, a very compact lay-out has been secured, as the entire building covers an area of but 25,520 sq. ft., or 1.52 sq. ft. per kilowatt of generating capacity.

Coal is received at the plant by a spur from the Baltimore & Ohio R. R., which extends over two track receiving hoppers of the conveyor systems in the boiler room and to a section of the yard in which provision is made for the storage piles. The receiving hoppers are fitted with crushers for reducing the coal to a uniform size, from each of which it is fed into a vertical McCaslin bucket conveyor for elevation to one of the rows of storage bunkers. It is distributed from the bucket conveyors to different portions of the storage bunkers by means of a 16-in. belt conveyor with adjustable tripping mechanism which facilitates trimming. The bucket and belt conveyors have each a capacity of 40 tons per hour and were installed by John A. Mead & Co., New York. The coal is drawn from the bunkers by automatic weighing down spouts which discharge directly into the stoker hoppers. The bunkers are of ¼-in. steel plate construction, with inclined sides, having a capacity of 650 tons.

There are sixteen Babcock & Wilcox water-tube boilers, each of 600-h.-p. capacity, installed in batteries of two each facing the cross firing floors. Four batteries have been installed on each firing floor, in longitudinal rows served by stacks 1 and 2, the longitudinal row of eight boilers at the rear to be served by stack 3, not having been installed as yet. The boilers are of the standard Babcock & Wilcox high-pressure construction with superheaters designed for raising the temperature of the steam 150° F. above that of saturation. Each has 294 4-in. tubes, 18 ft. in length, arranged in 21 sections. Each boiler is designed for a working pressure of 175 lb. and has a heating surface of 6,040 sq. ft. exclusive of the superheaters, which have effective heating surfaces of 1,180 sq. ft. The boilers are attractively finished and have their settings faced with white enamel brick.

The boilers are fired by Roney stokers, 9 x 12½ ft. in size, providing effecting grate areas of 111.8 sq. ft. The stokers of the plant are driven by two Westinghouse engines in the boiler room basement, one under each firing floor, which drive through lines of shafting under each row of stokers. Coal is delivered directly to the stoker hoppers by down spouts from the bunkers, while for ashes there are concrete-lined hoppers suspended below the furnaces of each setting. The breechings are located in the 11-ft. space between the top of the settings and the trusses supporting the bunkers. From each chimney two semi-circular steel plate breechings, 73 sq. ft. in section, extend to opposite longitudinal groups of four boilers. The connection to each setting is 21 sq. ft. in section, and is provided with a hand damper, while each main breeching connecting to a stack is fitted with a ball-bearing damper operated by an automatic damper regulator. The stacks are 200-ft. reinforced concrete chimneys, 12 ft. in inside diameter, built by the Weber Steel Concrete Chimney Co., and rise 183 ft. above the grates. All three stacks have been installed for the projected capacity of the plant, the third unit in anticipation of the third row of boilers which are to be installed at a later date.

Ashes are removed by industrial tracks in the basement, which extend under the rows of ash hoppers suspended from the boiler furnaces. The ashes are transported to the bucket conveyors at the side of the boiler room and raised into pockets alongside the coal bunkers. The same conveyor is used for elevating ashes and coal, the ashes being dumped from the narrow-gauge cars into a receiving hopper in the basement for feeding into the bucket conveyor. There are two 50-cu.-yd. ash pockets, one over each firing floor, located next the outer wall of the building to permit dumping directly into cars on the adjoining side tracks for removal.

The boiler ash pit hoppers are built entirely of reinforced concrete. They are 6 x 12½ ft. in plan at the top and 5½ ft. deep, the sides sloping at a very sharp angle, less than 30 deg., to prevent ashes lodging. The sides are of concrete 4 in. thick, reinforced by ½-in. rods at 6 to 9 in. spacing; the rods hook at the top into holes in a ⅜-in. steel plate ring supported from the steelwork of the setting, and at the bottom are bolted to castings which carry the outlet gates. Each hopper has three iron castings with 18-in. outlet openings, fitted with gates of the under-cut pattern operated from the basement. Three I-beam spacers which extend crosswise through the hopper are protected by sheet steel from the heat of the furnace. The front of the hopper is shelved over by a projection of the concrete flooring which extends to within 15 in. of the center line of the hopper to an I-beam support, the purpose of this shelf being to catch all unburned coal and siftings which may drop from the upper grates of the stoker.

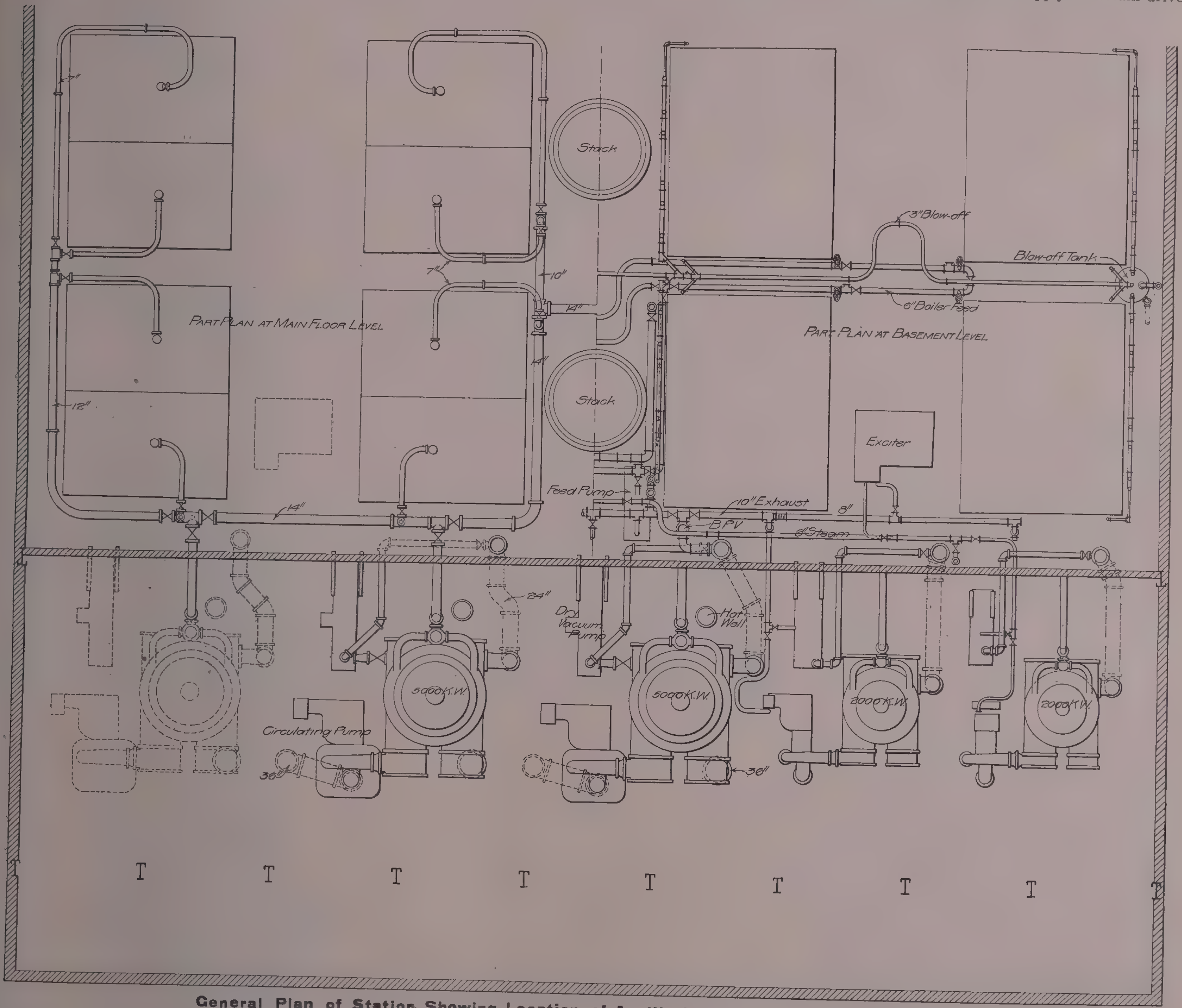
The boilers are fed by two Epping-Carpenter horizontal duplex pumps with 16x10¼x16-in. cylinders, while provisions are made for an additional pump when the remaining eight boilers are put in place. For the feed, the condensation returned from the condensers and drip systems is used, with make-up from the city's system and from wells. The feed is heated in two large Warren-Webster open heaters, purifiers and filters adjacent to stack 1, each capable of heating 200,000 lb. of water from 8° to 205° F. per hour. The heaters are supplied with exhaust steam from the auxiliaries, practically all of which are steam-driven for this purpose. The make-up water is stored in two cylindrical tanks, 8½ ft. in diameter by 8 ft. high, which are in elevated positions so as to supply the heaters by gravity as required. The two tanks have together a combined storage capacity of 50,000 lb. of water, and for filling them two Epping-Carpenter house pumps are used, each with 7½x10x10-in. cylinders. The pumps deliver under control of governors through a 6-in. ring main extending longitudinally in the boiler room basement between the two rows of eight boilers. From these, 2½-in. branches extend through the floor to each boiler unit, which renders the locations of feed graduating valves in them very central and convenient for the water tender. The feed piping is of brass throughout, and each boiler branch has two stop valves and a check valve in each of the steam drum connections.

The boiler blow-off system has a 3-in. main which extends to the rear of all boiler settings and leads to a blow-off tank near the southerly wall in the boiler room basement. Each boiler has three 2-in. blow-off connections from the mud drums, which connect into the main, and there are also 1½-in. blow-off connections from the lower drum of the superheater and from the rear of the steam drums. The blow-off tank is a cylindrical steel tank 5 ft. in diameter by 6 ft. deep, which has a 6-in. vapor connection to a roof exhaust head and a 5-in. overflow into the adjoining river, the overflow being so located as to maintain the tank partly filled with water at all times.

The steam piping involves a series of cross headers at the rear of each row of boilers, interconnected for purposes of universal supply. The cross headers taper, as shown in the accompanying plan drawing, from 10 to 14 in. in size, all boiler branches being 7 in., and turbine connections 10 and 12-in. lines. The headers are hung low to clear the breeching connections and all boiler branches have long radius horizontal bends. The sizes of pipe have been specially chosen by the designing engineers because of the use of superheated steam. As the turbines operate with 17 lb. of steam per kilowatt-hour, and as the volume of steam superheated 160° F. above saturation at 175-lb. pressure is practically 30 per cent. greater than that of the saturated steam, the velocity of the steam in the pipe will be approximately 7,800 ft. per minute. No separators have been installed in the superheated lines, but provision is made to drain the entire system by four 1¼-in. Squires traps, located in the basement of the boiler room, which return to the feed water heater. All of the piping is of steel with Van Stone joints and Chapman valves, and is covered with 85 per cent. magnesia.

A separate auxiliary steam header has been installed in the basement to supply all steam-driven auxiliary machinery. It is a 6-in. main, supplied at three points by 6-in. connections from the main superheated header above, and extends the entire length of the building. It is also fitted with a drip system which leads to two ¾-in. Squires steam traps for the removal of condensation which may possibly accumulate.

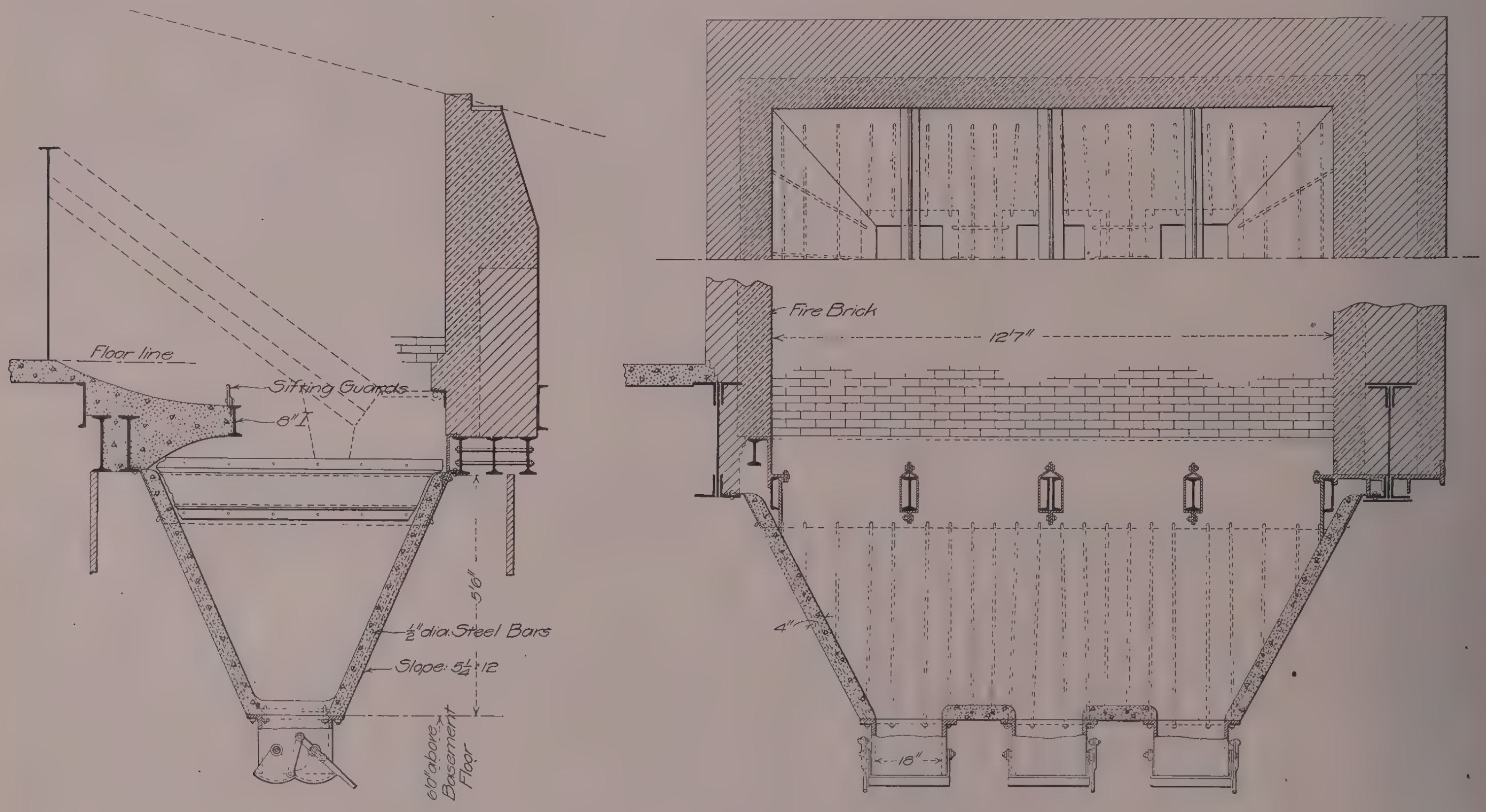
The steam turbines are of the base condenser type, the two 2,000-kw. units being four-stage and the 5,000-kw. units five-stage. All operate at 750 r.p.m. The attached generators are four-pole, 25-cycle, three-phase machines designed to deliver current at 6,600 volts. The first unit completed was turbine 3, a 5,000-kw. machine, which has



General Plan of Station Showing Location of Auxiliaries and Arrangement of Piping.

been in operation since the early part of December. The two 2,000-kw. now being installed have been used in the company's existing power plants. One is fitted with a separate condenser, but will, during installation, be reconstructed as a base condenser in order to render the entire equipment uniform.

The turbine foundations are combined with the condenser circulation tunnels in such a manner that piling under them has been avoided. The two circulation tunnels are rectangular conduits, each having a cross-sectional area of 40 sq. ft., which extend from the adjoining river longitudinally under the center of the turbine room to permit direct suction and discharge connections through the floor to the condensers. The conduits are built of concrete with the roof reinforced by old rails, and owing to their depth are made to serve as foundations for the steam turbine units. The spread of the tunnel footings is such that, with the entire load carried, including turbines and auxiliary machinery, the bearing does not exceed 1.8 tons per square foot, which was well within the carrying capacity of the soil at that point. This construction materially reduced the amount of concrete necessary for the foundation, and at the same time gave a most satisfactory arrangement for obtaining the circulating water.



Construction of Ash Hopper Used Under Boilers.

The condensers of the large units have a surface of 20,000 sq. ft. each, and those for the small turbines have a surface of 8,000 sq. ft. each. The auxiliary equipment of each unit is grouped around the foundation in a very compact arrangement. The 16 and 24-in. Worthington centrifugal circulating pumps are attached directly to the condenser casings with suction connections directly through the floor from the intake water tunnel underneath, while the condenser discharge is directly through the floor to the overflow tunnel on the opposite side. These pumps are direct connected to Harrisburg simple engines and have 36-in. suction and discharge connections for the larger units, and 20-in. suction and discharge for the smaller units. The dry vacuum pumps are the rotative, single-stage type built by the Laidlaw, Dunn, Gordon Co., those for the larger units having 12x25x18-in. cylinders and operating at 125 r.p.m., while those for the smaller units have 10x22x18-in. cylinders and operate at 125 r.p.m. The hot well pumps are the only electrical driven auxiliaries in the plant, being located in pits 5¾ ft. below the main operating room floor and driven from there by vertical shaft electrical motors. They are Worthington, two-stage vertical centrifugal pumps, 4 in. for the larger units and 3-in. for the smaller, and are driven by General Electric three-phase induction motors, 15-h.-p. for the larger units and 10-h.-p. for the smaller. The hot well pumps are connected to discharge condensation into a common header, which delivers it to the two feed water heaters in the boiler room, and the discharge connections are fitted with gate and check valves in order that, should one pump fail to work, the water of the other pump may not enter the pump not in operation. The discharge of each dry vacuum pump is connected to the exhaust riser from its turbine above the relief valve.

The exhaust connections from the turbines are very simply arranged, the exhaust stage of each unit opening directly into the condenser in its base. Each of the turbine units has, however, an individual atmospheric exhaust connection, which is 20 in. in size for the 2,000-kw. units and 24 in. for the 5,000-kw. units, these connections extending in all cases from the exhaust stage chambers to trenches under the turbine room floor into the boiler room basement and then through risers in the boiler room to roof exhaust heads. These risers are fitted with Blake back-pressure valves arranged for hand and automatic operation for relief of the turbines in case of failure of their condensers. The exhaust from the auxiliary machinery is fed into a common 10-in. header which extends the entire length of the boiler room basement. It has an atmospheric relief through a 10-in. Blake back-pressure-valve which connects into the atmospheric exhaust riser of turbine unit 3. Two 10-in. branches extend from the header to supply the feed water heaters, which are themselves independently vented to roof exhaust heads.

There are at present three pumps installed to supply oil to the step bearings of the various turbines, each of which is a 9x3⅛x10-in. Worthington duplex pump. The piping connections for these pumps are such that a single larger pump may be installed for this purpose later on if desired. The oil is returned after use to a 1,600-gal. collecting tank, from which it is drawn by an auxiliary pump into oil filtering and storage tanks. But one filtering tank and auxiliary pump are at present in use, although provisions are made for reserve units to be added later. The auxiliary pump is a 6x4x6-in. Epping-Carpenter duplex steam pump.

The two 100-kw. units furnishing current for the field excitation of the turbine generators and station lighting consist of 125-volt General Electric engine-type generators direct connected to 12x14-in. Harrisburg simple horizontal engines operating at 250 r.p.m. These units are located, as previously stated, in the open section of the basement facing the turbine room floor.

The switchboard and electrical control equipment of the plant are placed in three 15-ft. galleries on the outer side of the turbine room, separated from the engine room by a division wall, although the upper switchboard gallery is provided with large openings to permit the operators to overlook the turbine floor. The first floor, which is flush with the turbine room floor, provides for the generator leads and the outgoing cables, which are arranged in double tile ducts on the side of the wall. Access is had to them through a number of manholes in the side wall and in the underground cable conduits which extend from there to the various sub-stations. On this level are also installed the generator field rheostats and a toilet room. At a level 9½ ft. above this floor is the first gallery, which contains the oil switches and two bus sectionalizing switches controlling the generators and the outgoing feeders. These switches are of the cellular type, each pole being mounted in a separate concrete compartment, arranged in one row. Directly back of these cells are the bus bar compartments, and the static discharge and disconnecting switches are located in brick compartments between the bus bar compartments and the wall. The second gallery contains the control board, the generator section of which consists of five panels for the turbo-generators and two for exciter units. The feeder section is made of nine panels, three of which are for future equipment. These boards are constructed of black enamel slate of dull finish, mounted on pipe frame-work and contain all controlling switches, indicating instruments and apparatus for control of the high-tension circuits.

For the design and construction of this plant, J. G. White & Co., of New York City, served as engineers and contractors, also designing and installing the extensive high-tension transmission system with four large sub-stations for the local distribution in the city.

A Long-Span Stone Bridge.

A stone bridge 1,086 ft. long, consisting of seven spans, resting on piers spaced 157.5 ft. center to center, has recently been completed over the river Loire at Orleans, France. The clear opening of each arch at the springing line is 144.4 ft. and the rise is 19 ft. At the crown the arch is 4 ft. thick and at the springing line 4.7 ft. The main arches carry spandrel arches resting on piers 11.3 ft. center to center. The structure carries a roadway 31.3 ft. wide, two sidewalks, each 6.2 ft. wide, and a single-track car line, occupying a width of 8.5 ft. The bridge is very graceful in appearance and its estimated cost is given in "The Engineer," from which these notes have been taken, as £94,000, not including the amount appropriated for the purchase of land for the approaches, which brings the total estimated cost to £112,000.

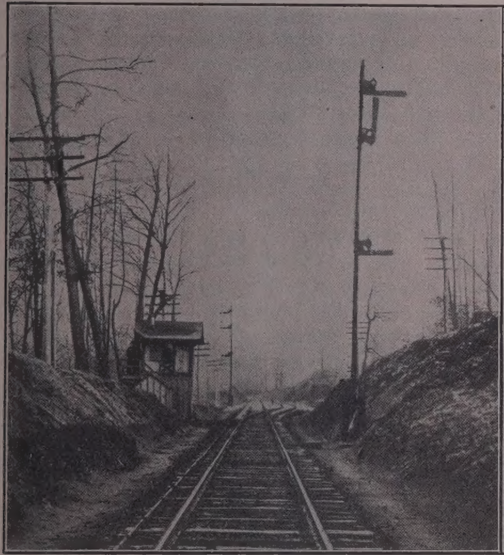


Fig. 1. Stop and Stay Signal.

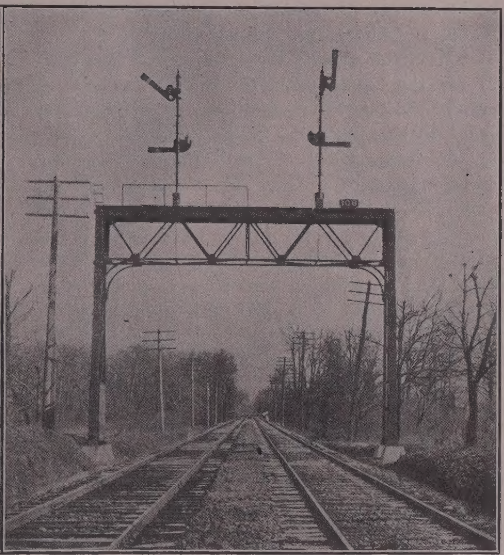


Fig. 2. Stop and Proceed Signal.

AN ELECTRIC RAILWAY which resembles very closely except in its method of traction a good many steam roads, is what is now known as the Atlantic Shore Line Ry. It now has 80 miles of line, which will be increased shortly to nearly 100 miles, thus affording an electric service between Dover and Portsmouth in New Hampshire and Berwick, Springvale, York, Kennebunkport and Biddeford in Maine. It employs electric locomotives for the heavier part of its freight business, which consists of hauling cars received from the Boston & Maine R. R., but most of its transportation is done with motor cars of the usual type.

A New System of Signals.

A new system of signals is being tried on the Pennsylvania R. R., and the results of its operation are of special interest owing to the fact that this new type will be used in the new Washington terminal. The system was devised by a committee appointed by the company to investigate existing methods of signal operation and to recommend a system which could be adopted over all of its lines. The committee's report has been fully discussed by both engineers and operating officials of the road, and as a result, the system developed is expected to combine the best features of train protection with proper provision for train operation.

The principles which govern the new arrangement are as follows:

First: Two arms and two lights will be displayed on every high signal. With existing signal arrangements the number of arms and lights is variable and depends upon track conditions so that there may be from one to five on a post. If any arm were broken or a light extinguished an engineer would probably not notice it, as he could not be expected to remember how many there were on each particular post, while if there were always two he would notice the slightest derangement of either of them. A small arm with a lower power light will, at times, be placed further down on the post or on a separate low post; but it will be so far away from the two main signals and of so much smaller size and less powerful light, that it will in no way interfere with the two arm and light principle.

Second: Day indications are given by three positions of the arm in the upper right hand quadrant, and at night each position is indicated by a different colored light. When the arm is horizontal a red light is displayed, when it is raised to an angle of 45 deg. a green light is displayed, and when it is still further raised to a vertical position a white light is displayed. Raising the arm above the horizontal has a distinct advantage over the usual practice of lowering it below the horizontal to an almost vertical position. Accumulations of ice, sleet, etc., on the arm tend to move it downward; with the new arrangement this would indicate caution or stop, while with the old arrangement the downward movement would indicate either caution, or proceed at speed.

Third: Three classes of signals will be employed: Class A.—"Stop and stay" signals which authorize or restrict train movements, and at which a train, if it is stopped, must stay until the signal is changed allowing it to proceed. This class includes interlocking, train order, controlled manual, manual controlled and telegraph block signals. They may be distinguished by the fact that the lights are vertically over one another and the arms appear the same length.

Class B.—"Stop, wait time and proceed" signals which authorize or restrict train movements and past which a train, if it is stopped, may proceed after waiting time, even though the signal has not changed and still indicates stop. This class includes automatic signals (and incidentally distant signals when the latter are used as independent indications). They may be distinguished by the fact that the lower arm and light are not distinctly under the upper arm and light, but located toward the left, so that the lower arm appears about 2 ft. shorter than the upper one and the lower light shows on the left hand side of the post, while the upper one shows on the right hand side. This staggered relation of the two signals is very noticeable both in daytime and at night.

Class C.—Signals which give information only and do not authorize or restrict train movements: Switch indicators, both home and distant; flag station, water tank and stop and slow signals, indicated by horizontal lights and special designs for day indicators. These signals are all low and do not interfere with the two-signal principle used on the high poles.

Fourth: Signals designate the speed of the trains rather than the routes, at points where interlocking systems are used.

The top arm governs the high-speed track, provided no cross-over movement is included in the route. It indicates proceed at highest speed permissible, modified, of course, by curves or any arbitrary order placed upon the speed.

The second arm governs medium speed movements, and refers to a divergence from the high-speed routes, such as an easy cross-over upon which a speed of forty or fifty miles an hour is proper.

The third arm governs low-speed movements; over short cross-overs, against traffic, into sidings, etc. This arm is shorter than the other two, has a short range light and is placed much lower down the post than the two main signals.

Interpretation of Signals.—Red light and arm horizontal—"Stop."

Green light and arm at 45 deg.—"Caution." Proceed to next signal which is now at "stop."

White light and arm vertical—"Clear." Proceed at speed, next signal at "clear" or "caution."

All interlocking signal arms remain normally in the horizontal position and at night show a red light. Arms are moved one at a time, so that an engineer could not pass any signal post unless the signal for his particular movement was at "Caution or Clear." The other signals on the post would all be at "Stop."

On signal posts where no high-speed route exists, the top arm is fixed in the horizontal position and the light is always red. At signal posts where no crossovers or moderate speed routes exist the second arm is fixed in the horizontal position and the light is always red. The only case when the top and second signals would both be out of horizontal position at the same time is on an automatic signal pole where the lower arm would act as a distant signal for a medium speed route controlled by an interlocked tower ahead.

The two interlocking plants of this installation are mechanical, but all signals are electro-pneumatic. Compressed air at 90 lb. per square inch and electricity at 500 volts are furnished from a centrally located plant. The air is transmitted through a 2½-in. main and the electricity, by a No. 6 B. & S. G. copper wire. Electricity for operating the track circuits and signals is taken from storage batteries located at various signals. The batteries are charged in series from the 500-volt supply, eight hours at a time, four nights a week. The batteries are type 5 E Chloride accumulators, each signal pole being supplied with 2 cells. One cell is used to operate the 16-ohm signal cylinder magnets and also to feed the track circuit in the rear through a 1-ohm resistance in connection with the rails. The other cell is in circuit ready for charging. The system of circuits is known as the "polarized wireless," the only wires used being those for the charging line, approach indicators, locks for interlockings and indication locks of the signals.

The signal cylinders are tandem and the arms are pulled "Clear" by a 3/16-in. rod instead of being pushed "Clear" by a ¾-in. pipe or a 1-in. rod. This new construction saves considerable power. The relays are 5-ohm universal, neutral polar and the pole changers are pneumatic. It has developed that an ordinary mechanical pole charger would probably be as well suited to the work.

All switches are equipped with rotary circuit controllers which shunt the track through two No. 6 B. & S. wires when switches are open. All boot-leg wires are No. 6 B. & S. plugged through web of rail with channel pins and running direct to battery, relay or pole changer without splices.

All sidings are equipped with pipe connected derails, a number of the Hayes type, operated from the main track switch lever. Both ends of the main line crossovers are operated through switch and lock movements from one ground lever placed in the middle of the cross-over tracks, making it impossible for careless trainmen to close the switches and clear the signals with a light engine standing on the crossover, and avoiding the use of special circuits to protect this danger point.

At first, trainmen unfamiliar with the device used too much force on this lever, and connections were sprung, or switch timbers moved. This trouble has practically ended, but it is thought that in future installations it will be preferable to use this lever to lock the points only for main track, operating them from ordinary switch stands, and thus making flying switches possible while insuring that switches must both be locked before the signals will clear, the circuit closer being operated by the lock itself instead of by the switch.

All interlocking home signals are power operated, semi-automatic controlled through stick indicators so arranged that they go to stop on the passage of train, and cannot be operated again until the train has left the circuit, and the operator restored his lever normal and again reversed it. Approach indicators and approach locking are provided, taking effect one block in the rear of the distant, and so arranged that if the home lever latch has been raised it cannot be put down to release the machine locking until a period of two minutes has elapsed. The circuits are so arranged that if a portion of the train is left on the approach circuit, the locking automatically releases when engine enters the home signal circuit, so that no hand or time release is required for ordinary trailing drill movements, but if a second train enters the section, the approach locking will become effective as soon as the home signal is cleared for it to proceed.

The slow hand release, so called, is really a time release, operated pneumatically and so arranged that it is out of control of the operator. Special lamps and brackets were provided, as it is known that with those in ordinary use the lost motion between the lamp socket and bracket were sufficient to allow the lens in many cases to angle so much to the side as to prevent its focusing properly along the track.

Fig. 1 shows a "stop and stay" signal. Note the clear indications given by the two signals at the top of the post. The second signal shows perfectly in its vertical position. The signals are directly under one another in this case and by comparison with Fig. 2, in which the second signal is offset to the left the visible difference between "stop and stay" and "stop and proceed" signals will be apparent.

At night this difference is very marked, for the signals are about 6 ft. apart vertically and the lower light is located 2 ft. to the left.

The installation has been in service about two months and its operation has been highly satisfactory. During the rush hours in the morning there are ten trains east in two hours and eight minutes, or a train every thirteen minutes, while two freights are working their way west with work to do on the eastbound track at various stations. In the evening when the commuter travel is westbound, there are nine trains in less than two hours, or a train every thirteen minutes, with generally one freight west and two east with work to do. Under these conditions the operation of signals is very frequent and the requirements for their proper operation to prevent delay and insure safety are very exacting. There are 40 signals in service, equal to 80 home and distant. During December there were three failures in operation—one due to broken wire, one due to weak battery and one cause unknown. The percentage of failures on the home and distant basis is, therefore, .038 per cent.

It is probable that if the system goes into general use the colors of lights will be changed as recommended by the Committee. The indication "clear" will be given by green instead of white, and the indication "caution" will be given by yellow instead of green. This change will do away with the use of a white light and is an important improvement, for the breakage of a red or green lens can now be made to give the indication "clear," while if the new arrangement of colors is adopted a broken lens gives a white light, which does not signify anything except that the signal is improperly displayed.

Book Notes.

Some time ago this journal called editorial notice to the importance of care in designing forms for concrete construction. It was pointed out that the cost of carpenter labor and lumber might become so great in the absence of careful attention to economy in these items that the expenditure for the concrete structure would become greater than that of other types of construction for the same purpose. This subject has been investigated for a number of years by Mr. Sanford E. Thompson, and at the third annual convention of the National Association of Cement Users he read a paper concerning it entitled "Forms for Concrete Construction." It not only discusses the design of forms but also goes into the details of the carpenter work and the removal of forms. In view of the importance of this part of concrete construction and the accidents that can be traced to defects in design or use of forms, Mr. Thompson's paper deserves a wide circulation. This fact has been recognized by the Association of American Portland Cement Manufacturers, which has long been using its influence to prevent the improper use of concrete and has published many bulletins giving valuable information on the subject. Mr. Thompson's paper has been added to these bulletins and can be obtained on application to the Association's office, Land Title Building, Philadelphia.

The latest addition to Longman's civil engineering series is a large volume by Mr. L. F. Vernon-Harcourt entitled "Sanitary Engineering with Respect to Water Supply and Sewage Disposal." It opens with some historical notes on water-works and a discussion of rainfall, evaporation and sources of water supply. There are two chapters on deep and shallow wells and the methods employed in sinking them, in which the description of working plant relates mainly to that used in England and on the Continent. Lakes and storage reservoirs are then taken up in their general features, and subsequent chapters give many details about dams, mainly masonry structures. In the chapter on intakes, aqueducts, service reservoirs and standpipes the general conditions governing the design of these structures are explained. The various methods of purifying water are described, and the author points out that water softening will probably soon come to be regarded as necessary in places supplied with hard water. The distribution of water is explained and the leading English types of apparatus connected with distribution pipes and services are illustrated. In the portion of the book devoted to sewerage, the author begins with the plumbing fixtures in the buildings, then takes up the street sewers and the methods of draining low-level districts by various patented appliances, and finally describes some of the large outfall sewers that have been constructed. The various methods of disposing of the sewage are then taken up and the leading features of sedimentation, chemical precipitation, irrigation, filtration and bacterial processes are explained. The book is a very general one, and particularly fitted for general reference libraries. (New York, Longmans, Green & Co., $4.50.)

A recent contribution to the literature on storage batteries is the work by Mr. R. W. Vicary, entitled, "The Treatment of Storage Batteries," which appears in pamphlet form. It is written by a man who has obviously had an extended experience with storage cells, but who is badly mixed on the why and wherefore of certain battery phenomena. As a plain, clear instruction book for the unskilled battery attendant it has many points of excellence, and in the questions of proper care and handling of lead-sulphuric acid cells gives much good, solid instruction. The theories, as set forth are, however, in many instances, wrong. For instance, the theory given of the chemical action which takes place on discharge is that the electrodes are both reduced from Pb and PbO_2 to PbO, by the action of the dissociated O and H, respectively, and then converted into $PbSO_4$ by a secondary chemical reaction between PbO and the H_2SO_4 of the electrolyte. That this theory is untenable from thermo-dynamical considerations was shown long ago. The chemical combination of PbO and H_2SO_4 is attended by the evolution of heat which is dissipated and represents lost energy. The high energy efficient of the lead storage battery precludes the possibility of any such heat loss. In reality the conversion of Pb and PbO_2 to $PbSO_4$ is a direct and complete electro-chemical reaction. The author also states that if the plates of a single cell in a battery become short-circuited all the other cells are likewise short-circuited through this same path. Since battery cells are customarily connected in series, it is difficult to see just how this condition could be produced, and, manifestly, the short-circuiting of a single cell has no effect on any others in series rotation with it. If, in taking a battery out of commission, the instructions given on page 48 of the book were followed, the ruin of all the negative plates would probably result. The relative value of "constant current" and "constant voltage" methods of charging are here discussed, although it has long been known that the only proper way to charge a cell is with a gradually diminishing current which is a maximum at the beginning of charge, and this method is the one in universal practice. This is not done with either a constant current or a constant pressure, nor does the author mention it as even a possible alternative way of charging.. (London, The Electric Accumulator, 15 Queen St., 2s. 6d.)

With the development of water-powers in northern climates has come a strong demand for reliable information concerning the nature of the ice which often clogs the racks and wheels of these plants during the winter, causing all manner of troubles. Fortunately Mr. Howard T. Barnes, associate professor of physics at McGill University, has been studying this subject for more than ten years and has gathered by experiment, observation, conversation with engineers and an examination of everything published on the subject, a large amount of data which he has presented in a valuable book entitled "Ice Formation, with Special Reference to Anchor Ice and Frazil." It is the first authoritative book on the subject since the publication of the report of the Montreal Flood Commission, long out of print. The opening chapter explains the physical laws governing the transfer of heat and is unfortunately the least interesting part of the whole book, so that the reader who attempts to judge of the work by this chapter will have a very wrong idea of its merits. In the second chapter Prof. Barnes has brought together from the original memoirs scattered through various scientific publications a large amount of information relating to the physical constants of ice, thus furnishing for the pyhsicist as well as the engineer a collection of data not elsewhere obtainable except at the expense of patient delving in a large scientific library.. In the third chapters the formation and structure of ice are considered, and the author gives a description of some very interesting experiments elucidating some of those features of the freezing of water which frequently cause controversy in engineering circles. The fourth chapter relates particularly to the origin and characteristics of sheet, frazil and anchor ice and contains useful practical information for engineers. One of its most interesting sections is a description of the ice phenomena in the lower St. Lawrence, taken from the report of the Montreal Flood Commission. The next two chapters describe the author's experiments with very delicate apparatus to determine the temperature of the St. Lawrence River at different periods during the winter. These experiments indicate that two distinct agencies cause the formation of frazil and anchor ice; the first is the direct contact of the water with the cold air, whereby heat is abstracted by agitation by either the wind or the churning of the water as it flows down rapids, and the second is terrestrial radiation, whereby an immense quantity of heat is radiated off into space under a clear sky. This gives rise to the great slabs of anchor ice which attain astonishing thickness on the bottoms of Canadian rivers that flow too swiftly for surface ice to form. The seventh chapter contains a detailed review of the many theories that have been advanced to account for frazil and anchor ice by engineers and other observers. The chapter is instructive as an indication of what a great diversity of opinion exists. In the last part of the book the author discusses the engineering aspect of the ice problem and explains the way in which it has been overcome at places where it formerly caused a great deal of trouble. The value of the book to the designers and operators of hydraulic power plants is self-evident, while the illustrations freely employed throughout the volume include reproductions of many striking photographs of ice conditions in Canada. (New York, John Wiley & Sons, $3.)

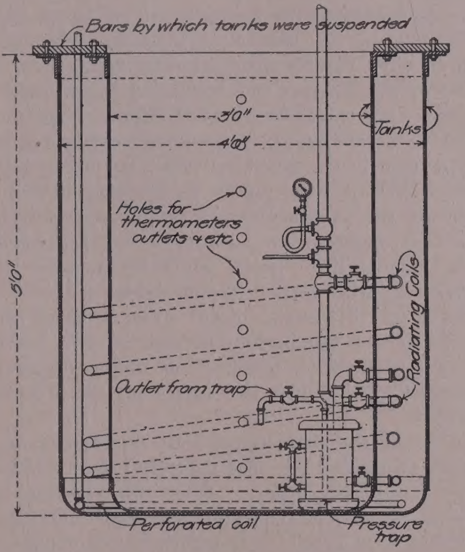
Letters to the Editor.

AMOUNT OF HEAT REQUIRED TO KEEP A PARTIALLY SUBMERGED METALLIC SURFACE FREE FROM ICE.

SIR: Some little time ago a series of experiments were carried on with the object of determining as accurately as possible, the amount of heat per square foot, which will be necessary to prevent freezing of partially submerged surfaces and also the best method of applying the heat; first, with air as the conducting medium, and, second, with water as the medium to conduct the heat to the surface of the exposed metal.

It was desired to carry out these experiments in such a manner that the results would have a practical value and, accordingly, the apparatus, as described below, was set up on the dam, between the upper and lower Mystic Lakes at Winchester, Mass., where the wind had full sweep and the weather conditions are as severe as are likely to be met in actual practice.

The plant consisted of a boiler set up in an abandoned gate house on the dam and the tanks, as shown in the sketch, the tanks being placed in the upper lakes about 30 ft. from shore and in about 35 ft. of water.



Tanks for Ice-Melting Tests.

The apparatus itself was designed with a view of covering conditions to be met in hollow lock gates of boiler plate and, to this end, two tanks, 5 ft. deep and 3 and 4 ft. respectively in diameter, open at one end, were constructed of boiler plate and bolted together as shown in the sketch, thus giving a water-tight annular space of 6 in. A ¾-in. pipe, perforated with 1/16-in. holes spaced about 4 in. apart on centers, was placed in the bottom of this annular space and was connected to the boiler through a vertical leg. In the center of the space, and covering a vertical distance of about 2½ ft. from the bottom were placed two steam coils so arranged with cut-off valves that either could be used separately or both in conjunction.

The steam consumption was measured by weighing the condensation which was caught by means of a pressure trap when the radiating coils were used, and by catching the overflow of drip pipes inserted in the inner tank at suitable intervals when the perforated coil was used to blow in live steam. The pressure and also the temperature of the steam at its entrance to the coils was accurately noted. Observations were also taken on the temperature of the air, the wind, the annular space and the amount by which the tank cleared itself from the ice which ran from 5 to 16 in. thick surrounding the tank.

The inside of the inner tank was lined with heavy asbestos paper and prevented radiation to any great extent from this surface. The top of the annular space was stuffed with hair felt and was thus insulated from the atmosphere. Suitable holes were tapped up and down the inside of the inner tank for the insertion of the overflow pipes and also for the insertion of thermometer cups to receive accurate thermometers for registering the temperature of the annular space at all points. All thermometers and gauges were carefully calibrated before and after the tests.

A wooden staging was erected and, from this staging the tanks were suspended by means of chain falls, which allowed the apparatus to be raised and lowered to any desired depth. A device was also rigged, by means of which the tanks could be clamped in any desired position.

Three methods of conducting the tests were followed, in each of which the tanks were submerged to varying depths. 1, The annular space contained air and was heated by the radiating coils. 2, The annular space was filled with water up to the lake level and heated by the radiating coils. 3, The annular space was filled with water up to the lake level and heated by blowing in live steam from the bottom.

Water of condensation was in each coil collected as above described, thus giving the steam consumption in pounds. The temperature of the condensation was also noted.

Corrections were made in all cases for the exposed portion of the apparatus above the water level of the lake, these corrections being obtained from tests previously run with the whole apparatus exposed to air only.

Readings of thermometers, gauges, etc., were taken every five or ten minutes, depending on the conditions or length of test, and the apparatus was nicely regulated by a man stationed within the tanks. The apparatus and the boiler house were in direct communication by means of a telephone.

In working up the tests the following assumptions were made: 1, That Newton's law of cooling is true and that the radiation of heat varies directly as the difference of temperature of the tank walls. 2, That, since a vertical boiler was used and the steam line connecting it to the apparatus was carefully covered with felting and also since the steam line was provided with open drips at all low points and the steam throttled at entrance to coils, the steam was dry. 3, No difference of temperature was assumed between the bottom of the annular space and the lake water. The temperatures of the thermometers warranted this assumption.

It was unfortunate that more tests could not have been run, as time allowed but fifteen in all, ranging from 2 to 4 hr. in duration, but from the results, as obtained, the following conclusions can be drawn.

Where time is an element to be considered, the method of using water as a conducting medium is much more efficient, since it will transmit the heat much faster. For reasons of difficulty of construction in the case of lock gates, rusting, corrosion, etc., it may be feasible to use air as the medium.

The water below the point of application remains at nearly a constant temperature. Hence, for heating the plate by means of water as the medium, either coils or live steam should be used.

Live steam gives up its heat more directly and quickly than steam in coils and consequently is slightly more efficient than steam in coils.

The air above the coils does not remain at constant temperature.

The amount of heat radiation from the surfaces exposed above the lake level depends more on the amount of wind than the temperature difference between the space and the atmosphere.

From these experiments it is probable that between 28 and 30 B. t. u. are transmitted per square foot of exposed surface per Fahrenheit degree difference between the sides of the plate per hour with water as the conducting medium. This is sufficient to clear the tank free of 3 or 4 in.

Using air as the conducting medium the above figure becomes from 2½ to 3 B. t. u. per square foot per degree difference per hour, and will free the tank but a slight difference from the surrounding ice.

Very truly yours,
Washington, D. C. Arthur E. Freeman.

Accidents in Reinforced Concrete.

Sir: A number of so-called "failures" in reinforced concrete structures have recently aroused considerable comment in both the trade press and newspapers. Some writers have seen fit to see in these accidents signs of inherent weakness in this method of construction. The vast majority, however, view the matter in a saner and more practical light, seeing in these incidents only the exigencies which attend any human enterprise.

The development of reinforced concrete work has been so rapid and vast in its extent that few people realize what a small percentage these accidents really bear to the total volume or how small the loss of life or property has been as compared to the loss of life in handling an equal amount of steel or other structural work. Careful investigation will prove, in fact has already proved, that the fault can in no way be blamed to reinforced concrete as a method of construction, but lies wholely with the lack of care and attention on the part of the individual in the handling of details. The tremendous volume of work now being carried on throughout the country has naturally drawn into employment a certain percentage of incompetent men. These are all matters of vital interest to every contractor and builder and the accidents before referred to, can have only a salutary effect in this direction.

To speak of a "failure of a reinforced concrete structure" is to imply that the work had been completed thereon in all essential details, and that after its completion it did not meet the requirements for which it was planned. Have you ever heard of the requirements for which it was planned? Have you ever heard of a reinforced concrete building that has proved a "failure" structurally? The writer never has, although he has investigated and observed several hundred reinforced concrete structures.

By way of illustrating the unusual strength and rigidity of reinforced concrete, let us refer to the San Francisco earthquake. A building in course of construction for the Bekins Van & Storage Co. was so shaken as to destroy the outside brick walls throwing them down on to the concrete floors and frames. The reinforced concrete remained absolutely intact even after subsequently being subjected to a severe fire test. There were a sufficient number of other examples in San Francisco to warrant investigators in the almost unanimous endorsement of reinforced concrete as the best-known material to resist earthquakes

A very unique example is reported in The Engineering Record, vol. 54, page 492, in the case of a six-story reinforced concrete building in Tunis. For various reasons this building settled unequally until an angle of about 25 deg. was reached, bringing the floor on the unheaved side fully 9 ft. above its normal height. No test could be devised to demonstrate more fully the monolithic character of reinforced concrete. By removing the earth under the elevated side, the building was allowed to regain its original vertical position. It would be impossible to compute the exact stresses that existed in this building during, and prior to, its restoration, but they were unquestionably very great and unusual.

The writer knows where many structural steel bridges were washed away and destroyed by the same floods that failed to damage reinforced concrete bridges in equally exposed locations. In one case where one pier of a reinforced concrete girder bridge was destroyed and carried away, the bridge itself remained standing and was used before repairs were made. Reinforced concrete floors of buildings have repeatedly been tested with heavy vibrating loads. These tests are of daily occurrence and some of the loads are from four to six times the designed load.

In view of the existing concrete work and the knowledge of experienced engineers on the subject, it is not within reason for the public to believe that there is an inherent weakness in this method of construction. In short, a concrete building properly designed and erected with proper material cannot be a "structural failure."

The following clipped from the February issue of "Everybody's Magazine" is significant; the record in reinforced concrete is trivial in comparison: "During the past year, Chicago skyscrapers exacted the heaviest toll of human life recorded in the history of building operations in the city. Figures compiled in the annual death-roll of the Bridges and Structural Ironworkers' Union show the increase in fatalities among the men to be enormous. Of a total membership of 1,358 men in the union last year, 156 either lost their lives or were totally or partially disabled. During the year before, twenty-six were killed, an equal number were so injured that they could not resume their trade, while the number of minor injuries totaled about eighty. This increase in the casualty list of from 10 to 12 per cent. of the membership during the two years was attributed to speeding up the work, thus compelling the men to neglect proper precautions."

One of the characteristics of reinforced concrete construction is that defects or faulty work are immediately apparent when the centering is removed. Every concrete building, therefore, undergoes a crucial test before it is completed. This is not the case in structural steel or other types of building. Many existing structures built of material other than concrete, contain weaknesses in both material and design, and only await the occasion of a real test to make these defects apparent. Similar weaknesses would exist in reinforced concrete if it were not for the test which must be incident to the removing of the centering, and in this manner the owners, as well as the public, are insured against a real failure. The writer is strongly of the opinion that a concrete building once completed is far safer than the average of all the existing structural steel buildings.

All the accidents in reinforced concrete occur, as has already been noted, about the time of the removal of the centering and are due usually to one of the following reasons:

1, Lack of care and good judgment in handling the removal of the centering, that is, placing sudden load on green concrete.

2, Poor or insufficient ingredients in the concrete which prevent proper setting.

3, Too early removal of forms.

4, Frozen concrete.

5, Faulty design.

6, Column form bottoms filled with rubbish preventing flow of concrete.

7, Overloading green concrete.

The fact that the removal of the centering will reveal the above defects, if they exist, even though it is sometimes accompanied by an accident, is a valuable property of reinforced concrete. The ultimate success of the use of this material is in its accidents, which are indeed stepping stones, so to speak, to its success. Intrinsically, each accident is a success because it prevents a "failure" which would, without doubt, be disastrous to the owner and the public.

If workmen can be restrained from becoming careless in removing centering, and proper superintendence and care are used in the removal, the risk of accidents in reinforced concrete work will be reduced to a minimum. With the careful removal of centering the defects are revealed in such a manner as to permit their being repaired without accident and at a minimum cost.

M. Goldenberg.
Detroit, March 4. Assoc. M. Am. Soc. C. E.

Resistance to Traction on Roads.

Sir: In your number of Feb. 23 there is a report of a paper by Mr. C. H. Hudson, on some experiments with an automobile to ascertain the retardation due to axle friction, wind and road resistance. While the author has attacked the problem in the right way, it is not quite clear how he reached the results given in the last part of the article. He expresses the distance his automobile travels as a function of the time, which is perfectly proper, but it is hard to see why the function should be one of the third degree. According to the law of falling bodies, the relations between space and time are: $s = gt^2 + at + b$. We are justified in assuming this relation, as we can assume that the vehicle attained its velocity by rolling down a hill having an effective height $h = v^2/2g$. It is, therefore, a fair question why the space expressed as a function of the time should change from a function of the second degree to one of the third.

It is also difficult to see how Mr. Hudson obtains the numerical values he gives for R out of his time-curve. By taking the first differential equation of his expression he, of course, gets an expression for the velocity of the moving body, but it is not clear how he derives from it the values for R corresponding to certain initial velocities. A shorter and clearer way to obtain the desired results is the following:

The instant the operator of the automobile releases the clutch, the car has attained a certain speed recorded by the tachometer. The kinetic energy, E, corresponding to this speed is $E = 1/2\ M\ (v^2 - v_1^2)$. M, the mass of the car, is equal to its weight W, divided by the accelleration of gravity, g. Assuming that $v_1 = 0$, the expression for kinetic energy becomes $E = Wv^2/2g$. This energy in this case is equal to the product of a force, R, into a distance, s, R being the retardation. This force, R, which is desired by the author of the paper, acts from the time the clutch is released until the car comes to a stop. Therefore $Wv^2/2g = Rs$, or $R = Wv^2/2gs$.

There is no introduction of the element of time in this expression, as it would simply add an unnecessary complication. For the whole testing operation, therefore, it is only necessary to know the initial velocity, v, in feet per second, the absolute distance, s, through which the car travels until it comes to rest, and the weight of the car.

It is certain that this resistance increases very much with increasing velocity, as is the case with a moving ship or a projectile in its flight. Consequently, it is doubtful if R at a velocity of 34 miles per hour is only 3.49 per cent. of the weight of the vehicle. It would be interesting to know the amount of this force, R, in the case of a heavy railroad train allowed to come to rest from a high speed. This force, which is transmitted into the trusses of a bridge, must be very large.

Yours truly,
Denver, March 2. H. Hagmaier.